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OF CHICAGO

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THE WEATHER AND CLIMATE OF CHICAGO

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INTRODUCTION

The task of preparing this publication has progressed rather slowly, because it was necessary to do the work at such times as regular office duties permitted. The preparation of the illustrations and tabular matter has covered a period of nearly five years, and it is because of the early completion of some of the graphs that they have not in every case been brought down to date. An effort has been made, however, to include in the various tables the most recent data available, and the records of 1913 have been entered as far as possible.

Were it not for the varying storm movement of the earth's atmosphere, the climate of any place would be determined largely by its distance from the equator, its elevation above sea level, and its surroundings, such as large bodies of water, level plains, and mountain ranges. In the middle latitudes, especially, the influence of storm movement is strong, and as a result endless changes in winds, clouds, rain and snow, heat and cold, etc., sweep the belt in which Chicago is situated, and cause variety in its weather conditions.

The city is located in latitude 41°35′ North, somewhat less than half-way from the equator to the pole, on a crescent-shaped plain gradually rising from the level of Lake Michigan, whose altitude is about 581 feet above mean sea level. This plain at its highest point is considerably less than 100 feet above the surface of the lake, and its greatest width is approximately 15 miles in a northeast-southwest direction. The whole plain is bordered inland by a glacial moraine which rises in places to about 150 feet above the higher portions of the plain itself. This rim is far too low to exert any appreciable effect upon the climatic or weather conditions of the city, and forms no barrier to either cold-wave areas from the west or hot winds from the southwest and south. Such barrier, however, is but infrequently needed, as many times the waters of the lake serve to soften the rigors of the wintry storms or to moderate the intensity of the summer's heat.

Located as it is at the southwest corner of the lake, Chicago is justly proud of its climate. As a consequence of the cool expanse of water in summer, the city often enjoys delightful and refreshing

breezes while the interior of the country away from the lake is sweltering in an air hot and still almost to the point of suffocation. The city is close to certain well-defined storm tracks, and the passage of these disturbances insures ample precipitation and interrupts the otherwise monotonous cycles of temperature and weather change. Chicago has been called the "Windy City," and the ensuing pages will show that there is some reason for the sobriquet, although the wind movement here is not much greater than it is at other places in the Great Lakes region. Its changes in weather are often sudden and pronounced, but usually are of such a character as to have a stimulating effect upon the average person of health; and it is not at all improbable that the great energy of its people, which has resulted in the rapid upbuilding of Chicago, is due largely to the peculiar nature of its climate.

In the various topics in this bulletin, the features of climate and weather are treated together. By weather we mean the passing conditions from hour to hour, and from day to day, while by climate we mean the sum total, as it were, of weather for many years. Hann says in his *Handbook of Climatology* (translated by Ward, p. 1):

> By climate we mean the sum total of the meteorological phenomena that characterize the average condition of the atmosphere at any one place on the earth's surface. That which we call weather is only one phase in the succession of phenomena whose complete cycle, occurring with greater or less uniformity each year, constitutes the climate of any locality. Climate is the sum total of the weather as usually experienced during a longer or shorter period of time at any given season.

By the method of treating climate and weather together, the data can easily be grouped or correlated under principal topics; that is, all temperature data, whether displaying climatic features or weather conditions, will be gathered under one general head of temperature, and similarly those for rainfall and snowfall will be gathered under precipitation, etc. For purposes of study this method will be found more satisfactory than that in which an effort is made to separate the different phases of the subject into two divisions, and it will be equally useful for reference. It is often very difficult to decide just where the dividing line between climate and weather runs; and, as a matter of fact, a compilation may in many cases be used to demonstrate the qualities of both.

In the chief divisions of this work, the order adopted is that of annual, seasonal, and monthly values, followed by the discussion of

daily conditions. It is recognized that the common custom in this respect has been reversed, but the arrangement makes possible the grouping of the daily values in great detail, so that the panorama of weather changes presented to the reader is unbroken, while at the same time the delineation of the various climatic features is as comprehensive as would be the case in any other order.

Temperature, precipitation, atmospheric moisture, cloudiness and sunshine, wind direction and velocity, and barometric pressure will be discussed in turn. The data on which these discussions are based are chiefly those of the official records, beginning with the establishment of the local Weather Office in October, 1870. A series of temperature and precipitation records prior to that time, obtained from observations made at certain points in Chicago or its vicinity, were available, and such have been used in the discussion of those subjects, in addition to the official data. The Weather Office has been moved from one location to another within the city on several occasions, and for various reasons, but chiefly in order to secure the best possible exposure for the wind instruments. Detailed references to these changes will be made at appropriate places in this bulletin.

The authors desire to express their indebtedness to Professor Charles F. Marvin, Chief of the United States Weather Bureau, for his kindness in reading the manuscript of this bulletin, and for many valuable suggestions in connection with the several subjects. Much use was made of Professor Oliver L. Fassig's work on the climate and weather of Baltimore (*Maryland Weather Service*, Vol. II), in determining the form and character of a great deal of the statistical data used in this volume.

The authors desire also to thank the following members of the force of the Chicago Weather Bureau office for their generous assistance in the preparation of the statistical matter and in reading the proofs: Mr. E. H. Haines, Mr. A. R. Thorson, Mr. E. C. Band, Jr., Mr. A. G. J. Kautz, Mr. F. J. Thomas, Mr. Wilfred P. Day, Mr. L. A. Cambridge, and Mr. C. I. Dague. Especial acknowledgment is due Mr. Band, who drew most of the graphs and figures.

PART I

TEMPERATURE

TEMPERATURE

When we speak of the temperature of the air we mean the measure of its condition with respect to heat at any particular instant. If, however, we wish to extend the term so as to convey knowledge of general conditions covering many successive instants—a day, a month, a season, or a year—we must combine the measures of the individual cases into average or mean values. The average of the temperatures observed at each of the twenty-four hours of the day gives the most satisfactory mean temperature for that period, but, in the absence of an automatically recording instrument, it is not at all times practicable to make the computation in such manner. Instead, the average of certain temperature values, which by long comparison have been found to differ but slightly from the mean of all the hourly readings, is substituted. The most common method in the United States is to divide the sum of the highest (maximum) and the lowest (minimum) temperatures of the day by 2, and this has been the practice of the Weather Bureau from 1872 to the present time. Previous to 1872 the average of the temperatures observed at 7 A.M., 2 P.M., and 9 P.M. was taken as the daily mean. Results obtained by either method ordinarily differ from the mean of the twenty-four hourly readings by less than ½° throughout the year.

In presenting temperature data for the various months, the terms *mean maximum* and *mean minimum* are in common use, and express the average of the daily maxima and minima, respectively. The mean temperature of any month is the average of its daily mean temperatures. We may obtain a close approximation of this by dividing the sum of the mean maximum and the mean minimum by 2, while the average of the mean temperatures of the twelve months of the year gives the mean temperature of that year.

When a series of mean temperatures for any month is averaged, the result is the mean monthly temperature for that month for that period, and its deviation from the *normal*—that is, the mean of a very large number of months—depends upon the length of the record. Similarly, the mean temperature of a series of years may be averaged, producing the mean annual temperature for that period, and if the period be sufficiently long, the mean value is the normal temperature of the year.

It is obvious that these various means, daily, monthly, and annual, must change slightly from year to year as long as there is not a sufficient record to smooth out the effects of abnormal conditions, and consequently they cannot be used to advantage in making comparisons. For this reason, mean values for certain periods are arbitrarily assumed or adopted as *normals*, and comparisons are referred to them rather than to the changing means. This distinction should be clearly borne in mind, as the terms *mean* and *normal* are sometimes confused. In this work, the word *normal* in the subsequent pages will designate the adopted normal, as the period of record is for most elements too short to produce mean values not liable to some change by succeeding observations.

Previous to the commencement of the observations of the Weather Bureau in Chicago in 1870, temperature readings as far back as 1830 were made at Fort Dearborn, the University, and at other places in the city, but prior to 1859 these observations were far from continuous. Since 1859 there has been no break in the series. During the periods of broken temperature records at Chicago, readings were made at various places in northern Illinois, mostly in co-operation with the Smithsonian Institution at Washington, D.C. In 1893, the late Professor Henry A. Hazen, in preparing his bulletin on the climate of Chicago, gathered up these old records and supplied for the city temperature readings for the years in which local observations were unavailable, by interpolating the data from the records made outside the city, but in near-by locations. The temperature data appearing in this book for the period prior to 1871 are taken from Hazen's *Climate of Chicago*. They are not official, and the manner of exposing the thermometers, and their environment, doubtless differed considerably from that of the present day. No definite information is at hand on the subject, so that we can take the readings merely for what they are worth. The thermometers of the Weather Office from its establishment until the removal to the Chicago Opera House Building, January 1, 1887, were exposed in a latticed shelter outside the office windows; but since the latter date the shelter has been located on the roof, the object being to place the thermometers in such a position as to protect them from sunshine or other direct radiated heat, and yet furnish the advantage of free air circulation. Apparent discrepancies in the unofficial records will later be pointed out, and examples given to show how much depends upon the location of the thermometer, and how the readings of instru-

ments, even in shelters not far apart, may differ appreciably. Because of these facts, the temperature data in this bulletin, and the discussion relative thereto, are confined chiefly to the period of official record, and a similar treatment is given the precipitation data which follow the subject of temperature. All entries relative to temperature are in the Fahrenheit scale.

MEAN TEMPERATURE, ANNUAL, SEASONAL, AND MONTHLY

Fig. 1 shows graphically the mean temperature of each year from 1830 to 1910, inclusive. The mean of all these years is 47°.7, while the adopted normal, based upon the Weather Bureau records from 1873 to 1905, inclusive, is 48°.5, and the mean of the official period from 1871 to 1910 is 48°.8. Table I presents the mean monthly and annual temperatures from 1830 to 1913, inclusive, and the means of these values by decades, as well as similar data for the different seasons. The monthly and annual adopted normals, 1873 to 1905, are shown at the top of the table. A month, year, or season having the normal temperature is, however, the exception rather than the rule, and it is interesting to note the departure (excess above or deficiency below) of temperature from the normal values for the various periods. These departures are presented graphically in Plate I.

Reliable temperature records kept in Europe at various places for more than a hundred years show that there has been no permanent change during that time, and meteorologists are generally agreed that no appreciable permanent change has occurred there during even the entire period of written and legendary history. Yet, were the data in Table I strictly comparable, we should be forced to the conclusion that the years are gradually becoming warmer, with but slight and temporary reversions to lower temperature. The mass of evidence from many other localities of long record is, however, against such a conclusion, and we must seek the explanation of the increasing means in changing conditions which might affect the readings of the thermometers used in securing the data. Granting that the observations of the unofficial period were made with the utmost accuracy, and that the interpolations are absolutely correct, and that the instruments used were all of the same standard, the question resolves itself into one of the nature of the locations of the thermometers and the influence of their environment upon the readings. Repeated experiments have demonstrated that the mean temperature in a large city is higher than that of the surrounding

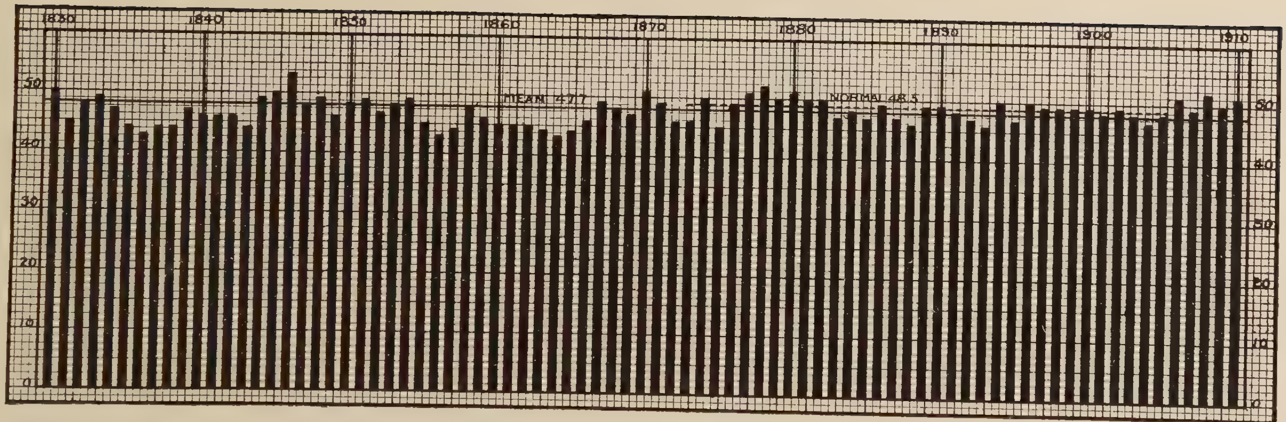


FIG. 1.—Annual mean temperatures.

Fig. 1 shows the mean annual temperature values based upon the data contained in Table I. The mean temperature line, 47°.7, represents the mean for the entire period from 1830 to 1910, while the normal temperature line, 48°.5, is the adopted normal, the mean of official observations from 1873 to 1905.

TABLE I

MEAN TEMPERATURE, ANNUAL, SEASONAL, AND MONTHLY, 1830–1912

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Winter	Spring	Summer	Autumn	Seasons
Normal temperature......	23.7	25.4	34.4	45.9	56.5	66.3	72.4	71.2	64.6	53.2	39.2	29.3	48.5	26.1	45.6	70.0	52.3	
1830	23	30	37	53	59	64	75	72	58	57	45	26	50	....	49.7	70.3	35.3	1830
1831	18	20	37	43	57	69	72	70	61	49	32	15	45	21.3	45.7	70.3	47.3	1830–31
1832	24	15	37	49	55	68	70.6	71.4	62.9	54.0	39.9	33.2	48.0	18.0	47.0	70.0	52.3	1831–32
1833	29.7	27.6	33.3	50.5	60.1	63.6	72.4	70.3	64.0	45.5	39.8	34.1	49.2	30.2	48.0	68.8	49.8	1832–33
1834	13.3	34.9	36.6	47.4	54.6	62.9	74.3	71.2	60.1	46.3	40.3	29.6	47.6	27.4	46.2	69.5	48.9	1833–34
1835	28.1	14.0	32.0	42.5	54.6	63.1	67.1	65.2	54.3	47.9	34.2	24.8	44.0	23.9	43.0	65.1	45.5	1834–35
1836	22.4	21.7	26.1	42.4	53.5	58.6	66.5	61.9	56.7	46.8	34.3	24.2	42.9	23.0	40.7	62.3	45.9	1835–36
1837	23	25	28	38	48	61	66	65	59	50	40	26	44	24.1	38.0	64.0	49.7	1836–37
1838	25	11	42	40	50	66	74	69	58	48	25	19	44	20.7	44.0	69.7	43.7	1837–38
1839	29	28	35	53	54	61	73	66	54	59	31	27	48	25.3	47.3	66.7	48.0	1838–39

1840	21	28	37	46	58	66	68	66	56	49	35	26	46	25.3	47.0	66.7	46.7	1839–40
1841	22	23	35	41	55	67	69	67	57	48	37	27	46	23.7	43.7	67.7	47.3	1840–41
1842	25	28	45	52	52	59	67	65	61	52	30	22	46	26.7	49.7	63.7	47.7	1841–42
1843	26	13	16	45	53	65	71	67	65	44	33	32	44	20.4	38.0	67.7	47.3	1842–43
1844	22	30.8	38.4	55.3	58.7	64	73.6	68	68.6	48	34	31	49	28.3	50.8	68.5	50.2	1843–44
1845	35	33	39	51	58	68	75	70	63	51	37	23	50	33.0	49.3	71.0	50.3	1844–45
1846	39	31	42	49	62	64	78	75	62	53	43	34	53	31.0	51.0	72.3	54.0	1845–46
1847	20	30	32	47	53	65	76	67	64	51	41	30	48	28.0	44.0	69.3	52.0	1846–47
1848	32	31	36	46	58	68	69	69	58	55	36	27	49	31.0	46.7	68.7	49.7	1847–48
1849	22	21	38	42	50	66	70	66	62	50	45	22	46	23.3	43.3	67.3	52.3	1848–49
1850	30	32	34	41	51	66	74	71	61	51	43	26	48	28.0	42.0	70.4	51.7	1849–50
1851	28	35	40	45	53	64	71	69	67	51	36	23	49	29.7	46.0	68.0	51.3	1850–51
1852	22	32	34	39	55	66	72	69	59	54	35	28	47	25.7	42.7	69.0	51.0	1851–52
1853	29.7	29.1	37	45	52	67	68	68	62	50	39	30	48	28.9	44.7	67.7	50.4	1852–53
1854	19	29	38	44	54	66	74	72	67	55	38	28	49	26.0	45.3	70.7	53.3	1853–54
1855	26	18	31	48	56	62	70	67	62	46	37	22	45	24.0	45.0	66.6	48.3	1854–55
1856	13	17	27	44	51	68	71	65	59	49	35	18.4	43	17.3	40.7	68.0	47.7	1855–56
1857	10.7	30.6	27.9	34.6	50.4	63.1	71.5	67.7	62.8	48.9	29.9	31.4	44	19.9	37.6	67.8	47.2	1856–57
1858	33	19	36	43	52	68	73	70	63	50	35	28	48	27.8	43.7	70.4	49.3	1857–58
1859	27	29	38	41	55	62	74	71	59	49	32.9	15.7	46	28.0	44.7	69.0	47.0	1858–59
1860	18.1	26.8	35.1	42.6	57.7	63.0	68.2	68.8	57.6	48.5	31.3	20.5	44.9	20.2	45.1	66.7	45.8	1859–60
1861	21.9	29.4	31.7	43.0	49.1	63.2	66.2	68.5	61.0	48.4	34.1	28.4	45.4	23.9	41.3	66.0	47.8	1860–61
1862	18.2	20.9	32.1	43.0	51.8	57.0	68.0	70.9	63.8	51.2	34.4	30.3	45.1	22.5	42.3	65.3	49.8	1861–62
1863	33.5	20.6	31.9	41.9	52.7	59.4	65.6	65.6	56.9	39.9	33.4	26.3	44.3	28.1	42.2	63.5	43.4	1862–63
1864	16.2	23.6	27.4	38.6	55.7	60.6	67.9	68.0	58.4	43.0	32.5	17.8	42.5	22.0	40.6	65.5	44.6	1863–64
1865	17.2	26.0	32.2	42.5	51.3	66.1	62.9	65.2	66.3	46.6	35.4	20.2	44.3	20.3	42.0	64.7	49.4	1864–65
1866	17.7	17.9	26.4	43.8	51.4	69.4	77.2	68.9	60.8	53.8	40.9	25.8	46.2	18.6	40.5	71.8	51.8	1865–66
1867	19.9	30.8	29.5	46.5	50.7	72.4	73.1	74.5	67.4	56.1	43.5	28.8	49.4	25.5	42.2	73.3	55.7	1866–67
1868	17.9	24.7	42.4	44.4	54.2	66.0	80.6	71.8	61.3	50.8	38.0	22.6	47.9	23.8	47.0	72.8	50.0	1867–68
1869	31.2	29.3	29.5	45.2	53.1	64.3	71.2	72.1	64.9	43.2	33.9	28.6	47.2	27.7	42.6	69.2	47.3	1868–69
1870	25.9	27.5	32.5	48.4	62.4	69.3	76.8	72.7	68.7	55.1	42.3	27.1	50.7	27.3	47.8	72.9	55.4	1869–70
1871	30.5	31.7	41.1	50.7	57.7	67.5	72.0	71.7	60.5	49.5	33.6	20.7	48.9	29.8	49.8	70.4	47.9	1870–71
1872	22.8	25.3	28.0	47.3	56.2	69.3	72.0	71.4	63.6	50.2	31.6	18.4	46.3	22.9	43.8	70.9	48.5	1871–72
1873	19.6	23.6	32.3	42.7	52.1	68.3	68.8	71.0	62.6	49.6	34.2	32.0	46.5	20.5	42.4	69.4	48.8	1872–73
1874	28.1	30.5	36.4	38.8	58.2	70.4	74.8	72.6	67.1	53.7	40.0	32.8	50.3	30.2	44.5	72.6	53.6	1873–74
1875	16.1	14.6	31.0	43.2	54.5	63.0	68.8	67.9	60.9	48.1	36.6	36.0	45.1	21.2	42.9	66.6	48.5	1874–75
1876	32.8	31.9	34.0	47.4	59.4	68.0	74.2	74.0	61.8	49.4	39.5	19.4	49.3	33.6	46.9	72.1	50.2	1875–76
1877	22.4	37.3	28.9	46.6	57.2	66.9	73.6	71.8	66.8	55.6	40.0	43.4	50.9	26.4	44.2	70.8	54.1	1876–77
1878	31.8	36.4	45.2	52.4	55.2	65.3	75.3	74.1	66.2	52.8	44.0	23.8	51.9	37.2	50.9	71.6	54.3	1877–78
1879	21.2	27.0	40.6	47.4	57.8	64.3	75.6	72.3	61.0	60.8	42.4	31.1	50.1	24.0	48.6	70.7	54.7	1878–79
1880	39.8	34.8	38.4	49.2	65.0	70.6	73.2	72.7	62.9	51.4	31.6	24.0	51.1	35.2	50.9	72.2	48.6	1879–80
1881	19.4	25.0	32.4	41.8	61.0	63.2	73.3	75.4	70.2	56.2	40.1	37.7	49.6	22.8	45.1	70.6	55.5	1880–81
1882	28.6	39.0	39.6	46.0	51.4	64.0	68.8	71.4	65.0	58.0	42.6	26.6	50.1	35.1	45.7	68.1	55.2	1881–82
1883	16.4	22.6	32.0	46.9	53.0	64.5	70.6	67.8	60.6	52.3	42.2	31.0	46.7	21.9	44.0	67.6	51.7	1882–83
1884	18.8	27.8	34.2	44.3	56.1	64.2	68.6	68.3	68.8	56.4	41.0	30.0	48.2	25.9	44.9	67.0	55.4	1883–84
1885	18.6	17.8	31.3	46.3	53.4	65.4	73.2	68.4	64.4	51.6	42.7	31.8	47.0	22.1	43.7	69.0	52.9	1884–85
1886	22.4	29.4	37.2	49.7	57.2	66.2	71.8	72.6	66.0	57.0	38.4	25.3	49.4	27.9	48.0	70.2	53.8	1885–86
1887	16.4	26.0	32.2	48.7	60.0	67.4	75.3	68.6	62.3	47.2	36.2	26.7	47.2	22.6	47.0	70.4	48.6	1886–87
1888	14.8	22.6	29.9	46.4	53.1	67.2	72.6	69.4	59.8	49.1	41.6	32.2	46.5	21.4	43.1	69.7	50.2	1887–88
1889	29.0	19.9	38.4	46.8	56.8	62.3	70.5	70.6	62.8	49.4	38.6	40.6	48.8	27.0	47.3	67.8	50.3	1888–89

TABLE I—*Continued*

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Winter	Spring	Summer	Autumn	Seasons
Normal temperature......	23.7	25.4	34.4	45.9	56.5	66.3	72.4	71.2	64.6	53.2	39.2	29.3	48.5	26.1	45.6	70.0	52.3	
1890	30.8	32.4	29.5	45.6	53.4	70.2	72.1	67.6	60.4	51.4	41.9	30.6	48.8	34.6	42.8	70.0	51.2	1889–90
1891	30.2	28.6	30.6	47.0	53.4	65.7	67.0	69.0	69.0	52.6	33.8	35.4	48.5	29.8	43.7	67.2	51.8	1890–91
1892	19.5	30.2	31.0	44.0	52.4	64.4	71.6	70.9	63.9	53.6	34.7	23.4	46.6	28.4	42.5	69.0	50.7	1891–92
1893	12.0	21.5	33.2	44.3	52.4	67.8	73.8	69.8	64.1	52.6	36.0	25.4	46.1	19.0	43.3	70.5	50.9	1892–93
1894	27.5	23.0	41.2	46.8	56.1	71.4	73.4	70.8	66.2	52.1	34.4	32.4	49.6	25.3	48.0	71.9	50.9	1893–94
1895	17.6	17.0	31.7	46.3	59.2	70.2	70.2	72.4	68.6	46.2	36.5	29.6	47.1	22.3	45.7	70.9	50.4	1894–95
1896	27.0	26.6	31.2	53.4	65.5	67.0	72.2	72.8	60.6	49.6	38.4	32.9	49.8	27.7	50.0	70.7	49.5	1895–96
1897	21.8	28.6	34.7	46.0	55.0	65.2	74.2	69.0	69.5	58.4	38.7	25.0	48.8	27.8	45.2	69.5	55.5	1896–97
1898	28.6	27.6	40.4	44.4	56.2	68.8	73.4	71.4	67.6	50.6	37.0	24.3	49.2	27.1	47.0	71.2	51.7	1897–98
1899	23.0	17.9	29.8	50.0	59.0	69.9	72.2	73.5	62.7	58.0	44.8	27.2	49.0	21.7	46.3	71.9	55.2	1898–99
1900	28.7	20.1	29.0	46.8	58.1	64.0	71.6	76.3	65.6	61.4	38.4	30.0	49.2	25.3	44.6	70.6	55.1	1899–1900
1901	26.0	17.0	34.0	45.0	54.1	69.1	77.4	71.6	64.3	55.4	37.6	24.0	48.0	24.3	44.4	72.7	52.4	1900–1901
1902	25.2	20.8	38.6	46.4	59.0	64.2	72.4	68.4	60.8	55.2	47.0	26.5	48.7	23.3	48.0	68.3	54.3	1901–2
1903	24.0	25.0	40.4	47.2	59.8	61.2	72.2	68.4	64.4	53.6	36.4	20.0	47.7	25.2	49.1	67.3	51.5	1902–3
1904	17.7	17.2	35.2	40.7	57.3	64.2	71.0	68.3	64.5	53.4	42.8	26.8	46.6	18.3	44.4	67.8	53.6	1903–4
1905	18.1	17.0	39.2	45.5	56.4	65.4	71.2	74.0	67.5	53.4	40.6	31.8	48.3	20.6	47.0	70.2	53.8	1904–5
1906	32.6	27.6	30.2	50.7	59.8	68.0	71.6	75.6	70.1	52.8	41.8	32.8	51.1	30.7	46.9	71.7	54.9	1905–6
1907	27.8	26.4	42.6	39.8	51.6	66.2	73.3	71.2	64.6	52.6	41.0	32.8	49.2	29.0	44.7	70.2	52.7	1906–7
1908	28.6	26.7	40.6	49.0	58.7	68.4	74.3	73.4	70.6	55.2	43.5	31.3	51.7	29.4	49.4	72.0	56.4	1907–8
1909	28.8	32.4	36.0	45.0	55.9	66.6	72.3	74.8	64.0	50.6	48.5	21.6	49.7	30.8	45.6	71.2	54.4	1908–9
1910	25.6	24.8	48.6	51.2	53.4	68.2	76.0	73.3	65.2	58.6	36.0	26.4	50.6	24.0	51.1	72.5	53.3	1909–10
1911*	29.2	32.4	39.2	46.1	65.9	72.4	76.0	71.8	67.0	53.2	35.4	35.0	52.0	29.3	50.4	73.4	51.9	1910–11
1912*	11.9	21.8	28.8	48.8	59.9	66.0	72.9	71.0	67.7	55.8	42.8	33.4	48.4	22.9	45.8	70.0	55.4	1911–12
1913*	29.3	24.8	35.2	48.8	57.6	70.5	74.9	74.3	65.4	53.3	47.2	37.4	51.6	29.2	47.2	73.2	55.3	1912–13
Mean 1830–39	23.6	22.7	34.4	45.7	54.6	63.7	71.1	68.2	58.8	50.4	36.2	25.9	46.3	23.8	45.0	67.7	48.4	1830–39
Mean 1840–49	26.4	26.9	35.8	47.4	55.8	65.2	71.7	68.0	61.7	50.1	37.1	27.4	47.7	27.1	46.4	68.3	49.8	1840–49
Mean 1850–59	23.8	27.1	34.3	42.5	52.9	65.2	71.8	69.0	62.2	50.4	36.1	25.0	46.7	25.5	43.2	68.8	49.7	1850–59
Mean 1860–69	21.2	25.0	31.8	43.2	52.8	64.1	70.1	69.4	61.8	48.2	35.7	24.9	45.7	23.3	42.6	67.9	48.6	1860–69
Mean 1870–79	25.1	28.6	35.0	46.5	57.1	67.2	73.2	72.0	63.9	52.5	38.4	28.5	49.0	27.3	46.2	70.8	51.6	1870–79
Mean 1880–89	22.4	26.5	34.6	46.6	56.7	65.5	71.8	70.5	64.3	52.9	39.5	30.6	48.5	26.2	46.0	69.3	52.2	1880–89
Mean 1890–99	23.8	25.3	33.3	46.8	56.3	68.1	72.0	70.7	65.3	52.5	37.6	28.6	48.4	26.4	45.4	70.3	51.8	1890–99
Mean 1900–1909	25.8	23.0	36.6	45.6	57.1	65.7	72.7	72.2	65.6	54.4	41.8	27.8	49.0	25.7	46.4	70.2	53.9	1900–1909
Mean of official record, 1871–1910	24.1	25.6	35.3	46.3	56.5	66.5	72.4	71.4	64.8	53.2	39.3	29.1	48.8	26.3	46.0	70.1	52.4	1871–1910
Means, 1830–1910	24.0	25.6	34.7	45.6	55.4	65.6	71.9	70.0	63.0	51.5	37.8	27.3	47.7	25.3	45.2	69.2	50.7	1830–1910

* Not included in means.

Table I shows the mean monthly, seasonal, and annual temperature for Chicago for the years from 1830 to 1913, inclusive, and the monthly and annual normals, 1873–1905, inclusive. The data previous to November, 1870, when the Signal Service (now Weather Bureau) record begins have been taken from Hazen's *Climate of Chicago*, which contains observations as far back as 1830. Some of these observations were made at Fort Dearborn, others by volunteer observers of the Smithsonian Institution, while still others have been interpolated from temperature records at other points in Northern Illinois which overlap those of the Weather Bureau. Since 1859 the temperature record at Chicago has been continuous, secured, of course, from instruments at various exposures.

country, provided the topography is fairly uniform. This is largely because of the lower night temperatures in the country, due to freer radiation of heat as compared with the city, where radiation is retarded by smoke and otherwise influenced by the character of pavements and buildings. These city conditions change gradually, of course, with the growth of the place and as it passes through the village stage to that of a large city, and ultimately becomes a great metropolis, the temperatures in the central portion are held up higher and higher each year of growth, so that the readings of a thermometer kept in the same position throughout the whole time would indicate a climatic change to warmer, while one similarly placed in the open country would maintain a fairly even record throughout the years.

Moreover, the locations of the Chicago thermometers were frequently changed, and, as will be pointed out later in more detail, the position of the instrument with respect to surface inequality, height above the ground, protection from direct radiated heat, and air movement, affects its action to a greater or lesser extent, and produces different results in thermometers separated by comparatively short distances.

The mean annual temperatures, even during the period of official readings, have doubtless been influenced in a large measure by changes in the exposure of the instruments, and a comparison of the mean temperatures at the four different locations in the city where the Weather Bureau has successively maintained its office should prove interesting, and bear out the statement of the previous paragraph. These data (Table II, Fig. 2) are not synchronous, nor do they even partially overlap, and as a result no exact allowance can be made for change of location, but the evidence regarding the general effect of such changes is plain. According to the actual means the temperature during the three years at the Chicago Opera House Building was lower by 2°.6 than it was during the six years at the Federal Building, while the means at the Major Block and at the Auditorium Tower lie between these extremes. Owing to several remarkably warm, and but few cold Februaries, the mean of that month at the Major Block is higher than that of any of the other locations; but, as a rule, the means are highest at the Federal Building. The length of record at the latter, however, is entirely too brief for the determination of normals for that location, and this is also the case at the Chicago Opera House Building. The very short period of record at this place will account for some of the apparent discrepancies in the

means, such as the high average for December, as when the number of factors entering into the mean is small, accidental abnormalities control the resulting value to a large extent.

TABLE II

MONTHLY AND ANNUAL MEAN TEMPERATURES, FOUR DIFFERENT EXPOSURES

Location	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Major Block....	24.3	28.8	35.5	46.2	56.9	65.8	72.2	71.4	64.6	53.8	39.6	30.4	49.1
Chicago Opera House........	22.8	22.8	33.5	47.3	56.6	65.6	72.8	69.5	61.6	48.6	38.8	33.2	47.8
Auditorium Tower........	23.1	23.2	34.4	46.2	56.7	66.8	72.3	70.7	64.8	53.6	38.6	27.6	48.2
Federal Building	28.7	27.6	39.6	47.1	55.9	67.5	73.1	73.2	67.0	53.9	41.9	29.4	50.4

Table II contains the average monthly and annual temperatures at Chicago for four different exposures, not synchronous, located as follows: Major Block, June 8, 1873, to December 31, 1886; Chicago Opera House Building, January 1, 1887, to January 31, 1890; Auditorium, February 1, 1890, to June 30, 1905; Federal Building, July 1, 1905, to 1912.

Elevation of thermometers above street as follows: Major Block, 70 feet; Chicago Opera House Building, 146 feet; Auditorium, 241 feet; Federal Building, 140 feet.

Thermometers in each case exposed in lattice-work shelter on the roof of the building, except at the Major Block where the shelter was outside an office window on the north side. For graphic comparison see Fig. 2.

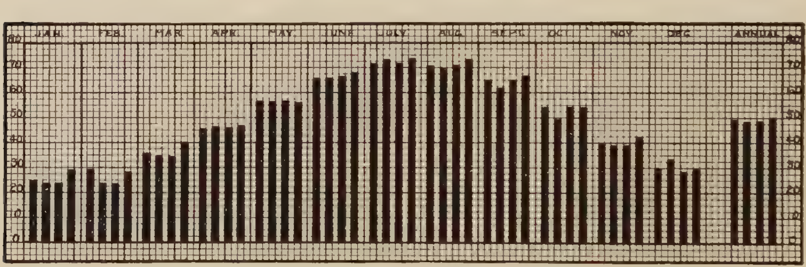


FIG. 2.—Average monthly temperature; four exposures.

First column of each set, Major Block; second, Chicago Opera House Building; third, Auditorium Tower; fourth, Federal Building.

Previous to 1905, upon the removal of Weather Bureau offices from one location to another, it was not customary to make synchronous comparative observations between the instruments at the old and the new quarters. Following the removal from the Auditorium Tower to the Federal Building on July 1, 1905, however, comparative readings were made for a period of six months at both old and new locations, and they afford an interesting study of relative conditions. During this time the mean temperatures averaged 1°.7 higher at the Federal Building than at the Auditorium. The daily maximum and minimum temperatures for August and December, 1905, respectively, are shown graphically in Fig. 3, the Federal Building values averaging

1°7 higher in August, and 1°8 higher in December. There seems no reason to doubt that the difference in location alone is responsible for the temperature at the Federal Building averaging 1°7 higher than is the case at the Auditorium, and applying this difference to the annual mean at the former, as shown in Table II, the value would be reduced to 48°7, thus indicating the true mean for the 5½ years at the Federal Building on the basis of the Auditorium record of the previous 15 years, 48°2. In other words, if the record had been continued without change of location after July 1, 1905, the mean temperature for the period of 5½ years ending with December, 1910,

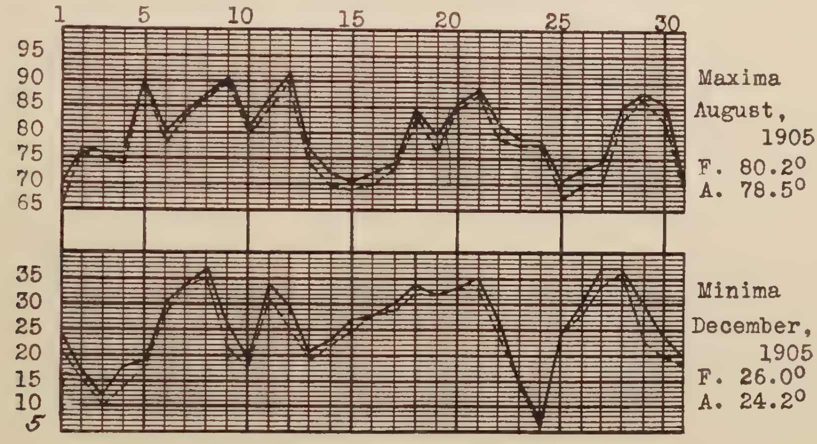


FIG. 3.—Maximum and minimum temperatures.

Auditorium - - - - - - - - - -
Federal Building ——————

would have been about 48°7 instead of 50°4 as obtained at the Federal Building; and the difference is caused by the change of location of the thermometers, the present one being three blocks farther from the lake, and in the midst of the loop or business district, where the instruments are more affected by the heat of great buildings and other city conditions. Then, too, the corrected mean of 48°7 for the Federal Building is 0°4 lower than the 14-year mean at the Major Block, 49°1, instead of 1°3 higher, as shown by the available records. The periods of observation at both Major Block and Auditorium are sufficiently long to establish fairly accurate mean temperatures for their respective localities, and while they are separated by an interval of four years, we should expect the mean at the

former to be the higher, and this is found to be the case, the values being 49°1 and 48°2, respectively. The Major Block is well within the loop district, and even farther from the lake than is the Federal Building. As a consequence, its location favored a higher temperature than that at the Auditorium, and one slightly higher than that at the Federal Building; while the fact that the thermometers were exposed in a window shelter at the Major Block would in itself be responsible for slightly higher temperatures than at the other locations, where roof shelters were used. The activities were not as intense in the business section from 1873 to 1887 as in later years, and therefore heat from the buildings could not have affected the situation quite as much as is the case at present at the Federal Building. The period of observations at the Chicago Opera House Building was only three years—entirely too short to give a reliable mean, and the value of 47°8, the lowest of any of the locations, may be misleading unless this fact is considered. The location, in fact, would favor a higher temperature than that at the Auditorium, but the average was 0°4 lower, and is due rather to actually colder weather during the period in which these readings were made. A number of the months during 1887 and 1888 were exceptionally cold, the low temperatures of which served to lower considerably the mean temperature, not only of the years themselves, but also of the mean for the three-year period.

The foregoing paragraphs illustrate the influence of location and exposure upon mean temperature at points several blocks apart, but differences are often caused by the surroundings of the observation point within quite small limits, and are due to irregularity of surface, character of street pavings, height and facings of buildings, and many other features peculiar to the particular area under consideration; and, in addition, to the varying conditions of cloudiness, sunshine, and air movement.

In 1909 the Weather Bureau established for the benefit of the public in Chicago a set of instruments in a specially constructed shelter, or kiosk, at the southwest corner of Adams and Dearborn streets, under the walls of the Federal Building, on the roof of which, 140 feet above, are exposed the official thermometers. A series of readings, taken during the months following in that year, to determine the difference between the kiosk and the official instruments, furnishes interesting confirmation of the statements above. The observations indicate daytime temperatures (maxima), whose

variation from the readings of the station instruments depends closely upon cloudiness and sunshine, and night time temperatures (minima) of nearly constant difference. Throughout the period the daytime temperatures averaged at the kiosk on clear days 3°.7 higher than the station instruments on the roof near by; while on cloudy days the excess was but 1°.3. Some portion of these differences, probably somewhat less than 1°, may be directly attributed to the difference in elevation between the kiosk and the roof shelter, and would reduce the excess due to other causes on cloudy days to practically nothing, and point to the conclusion that the environment of the kiosk—the pavements, the building walls as artificial barriers to air movement—together with the heating by insolation of the iron structure of the kiosk itself, is directly responsible for the pronounced differences in temperature on days of sunshine. It was noted, however, that the temperatures did not begin to rise in the morning at the kiosk as early as in the shelter on the roof, as on account of the high buildings the direct rays of the sun did not reach the street until some time later; while on account of shading soon after the middle of the day, the fall began sooner than on the roof, and was rather more gradual. Occasionally, also, when the official maximum was delayed until very late in the afternoon, the kiosk maximum, even on a day of bright sunshine, did not, on account of this shading at street level, rise as high as that on the roof.

The night temperatures showed an average excess at the kiosk of 0°.9 and 1°.1 for clear and cloudy weather, respectively, indicating a greater loss of heat at the street location when conditions for radiation were good. It will be noticed that the excess is practically constant in cloudy weather for both day and night, the cloud blanket above preventing excessive heating at the kiosk during the day, and equalizing the conditions of radiation at night.

Differences such as those described may be noted in many portions of the city, and in some locations are even more pronounced, especially in so far as night radiation is concerned. Thermometers exposed in the more sparsely built sections of the city, or in many of the suburban districts, show often much lower temperatures on quiet, clear nights than do the official instruments in the loop, influenced as are the latter by overhanging city smoke and the immense structures near by. This difference has been noted in special cases to be as much as 14°, and explains why at certain times the Weather Bureau thermometers in the city are well above the freezing point,

while ice and frozen surfaces are general in the outlying sections. It will be apparent from this that the official record must be regarded simply as a statement of the temperature conditions at the point of exposure of the instrument; and the person interested in any particular locality of the city must establish, if only roughly, his own "table of differences" if he wishes to use the local forecasts and temperature data intelligently.

While the best exposure for a thermometer is in a latticed shelter on the roof of a building or over sod, a satisfactory location may often be found under a veranda with a north exposure, the position being such that the direct rays of the sun are kept from the instrument. Should the sun shine upon the thermometer, the reading will be in excess of the air temperature at that point, the difference depending on the character and proximity of radiating surfaces similarly exposed. It would, however, indicate approximately the degree of heat experienced by a person exposed to the sun's rays at that location. Radiating surfaces of dark color influence the readings to a much greater extent than those of lighter shades. During cloudy weather the character of the exposure is not of the importance shown above, but the clearer the atmosphere the greater is the difference between the readings of a thermometer under shelter and one in the open. During the two warm days of September 2 and 7, 1913, at Chicago, when the official maximum readings were 97°.1 and 92°.7 a thermometer exposed near by in the sun registered 112°.8 and 110°.2, respectively, the difference being as much as 17°.5 on the 7th, a Sunday when the atmosphere was clear with the exception of a few fleecy upper clouds. On week days, when there is more smoke in the atmosphere, the differences between sun and shade temperatures are not often great, while on clear, dry days, especially in the suburbs away from the smoke of the city, it is probable that the differences will range sometimes from 20° to 30°. Greely in his *American Weather* cites an instance in the Arctic of snow melting on a dark surface when the temperature of the air was 18° below zero.

In view of the various cases of differences described above, it will readily be understood why we are loath to use unqualifiedly for purposes of comparison the old records of temperature made prior to 1871, and it is for the reasons outlined that very little attention will be given them in this bulletin; while in the detailed statements concerning the official records, the reader should bear in mind the

various locations of the Weather Bureau office, and the length of time it remained at each place.

Fig. 2 will serve to show the monthly march of temperature, from the minimum in winter to the maximum in summer. The variations, of course, are not all of the same amount. Based upon the normals, as derived from the record of 1873–1905 (see Table I), the average changes from month to month are given in Auxiliary Table A.

AUXILIARY TABLE A

January to February	+ 1°.7	July to August	− 1°.2
February to March	+ 9°.0	August to September	− 6°.6
March to April	+11°.5	September to October	−11°.4
April to May	+10°.6	October to November	−14°.0
May to June	+ 9°.8	November to December	− 9°.9
June to July	+ 6°.1	December to January	− 5°.6
January to July	+48°.7	July to January	−48°.7

DEPARTURE FROM NORMAL TEMPERATURE, MONTHLY AND ANNUAL

There are two ways in common use of showing the abnormal features of a month or year: one is to use the difference between the mean temperature of the period and the normal temperature, the other is to carry the algebraic sum of the daily departures throughout the period, the final value representing the departure for the month or year. These are called accumulated departures, and possess the quality of being more vivid, or easier to understand. To say that a year has exceeded the normal by 3½° does not at first strike the average person as much out of the ordinary; but to say that during the year 1,262° of heat more than usual were experienced attracts the attention at once as exceptional.

In Table III are given the accumulated monthly departures for each month, and the accumulated annual departures for each year of the official record. The highest and lowest departures are printed in heavy type, and indicate the warmest and coldest months and years, respectively. A study of this table and of the one following (Table IV), which give the departures accumulated through the months of each year reaching finally the annual value in December, should serve to illustrate further the character of the monthly and annual temperatures as shown in Table I, Fig. 1, and Plate I. The mean values at the bottom of the table prove, as might naturally be expected, that the most variable of the months are those of the winter season, and that the summer departures are scarcely more than one-third in amount as compared with those of the cold period. The

decrease and increase in the amount of departure are fairly uniform throughout the year with the exception of May, which shows

TABLE III

Monthly and Annual Departures from Normal Temperature, Expressed in Degrees, 1871–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Normal monthly heat.....	734	711	1066	1376	1753	1990	2243	2208	1939	1650	1175	909	17754
1871.......	+211	+176	+207	+144	+ 37	+ 36	− 12	+ 16	−123	−115	−168	−267	+ 142
1872.......	− 28	− 3	**−198**	+ 42	− 9	+ 90	− 12	+ 6	− 30	− 93	**−229**	**−338**	− 802
1873.......	−127	− 50	− 64	− 91	−137	+ 59	−111	− 2	− 60	−110	−151	+ 84	− 760
1874.......	+138	+144	+ 66	**−200**	+ 49	+121	+ 75	+ 52	+ 75	+ 14	+ 36	+109	+ 679
1875.......	−233	**−297**	−108	− 77	− 59	−102	−115	− 97	−111	−161	− 78	+207	**−1231**
1876.......	+276	+184	− 14	+ 47	+ 92	+ 48	+ 56	+ 85	− 82	−120	− 14	−308	+ 278
1877.......	− 48	+332	−169	+ 19	+ 19	+ 20	+ 38	+ 19	+ 63	+ 72	+ 28	**+436**	+ 829
1878.......	+252	+312	+333	+193	− 39	− 30	+ 92	+ 91	+ 46	− 11	+142	−170	+1211
1879.......	− 75	+ 44	+191	+ 41	+ 40	− 58	+101	+ 34	−104	+235	+101	+ 55	+ 605
1880.......	**+501**	+265	+122	+102	+259	+129	+ 27	+ 47	− 53	− 56	**−229**	−163	+ 951
1881.......	−132	− 9	− 61	−123	+142	− 94	+ 34	+127	+152	+ 88	+ 25	+262	+ 411
1882.......	+154	**+382**	+159	+ 8	**−156**	− 69	−114	+ 1	+ 9	+149	+100	− 83	+ 540
1883.......	−227	− 79	− 71	+ 30	−110	− 57	− 52	−103	−123	− 33	+ 88	+ 52	− 685
1884.......	−151	+ 72	− 6	− 45	− 9	− 64	−120	− 87	+122	+ 98	+ 50	+ 19	− 121
1885.......	−151	−224	− 95	+ 7	−100	− 31	+ 22	− 89	− 7	− 50	+102	+ 77	− 539
1886.......	− 40	+136	+ 83	+116	+ 17	± 0	− 15	+ 43	+ 40	+111	− 23	−124	+ 344
1887.......	−226	+ 14	− 69	+ 84	+102	+ 28	+ 96	− 83	− 69	−185	− 81	− 81	− 470
1888.......	−274	− 86	−140	+ 17	−111	+ 27	+ 7	− 62	**−145**	−118	+ 72	+ 90	− 723
1889.......	+164	−165	+128	+ 32	+ 9	−122	− 58	− 19	− 58	−120	− 19	+347	+ 119
1890.......	+223	+198	−154	− 11	− 99	+116	− 9	**−114**	−126	− 58	+ 83	+ 36	+ 85
1891.......	+202	+ 94	−113	+ 35	− 95	− 19	**−169**	− 68	+129	− 19	−167	+186	− 4
1892.......	−129	+136	−104	− 55	−126	− 58	− 24	− 13	− 20	+ 11	−134	−182	− 698
1893.......	−364	−108	− 37	− 47	−128	+ 47	+ 44	− 30	− 19	− 19	− 98	−125	− 884
1894.......	+119	− 68	+215	+ 33	− 11	+153	+ 30	− 12	+ 44	− 42	−146	+ 93	+ 408
1895.......	−191	−236	− 82	+ 7	+ 80	+110	− 68	+ 38	+121	**−217**	− 80	+ 6	− 512
1896.......	+103	+ 30	− 97	**+226**	+275	+ 20	− 2	+ 48	−123	−117	− 22	+116	+ 457
1897.......	− 54	+ 88	+ 9	+ 4	− 48	− 39	+ 57	− 70	+143	+158	− 15	−132	+ 101
1898.......	+153	+ 61	+184	− 45	− 12	+ 72	+ 31	+ 10	+ 91	− 77	− 62	−155	+ 251
1899.......	− 27	−211	−145	+124	+ 78	+107	− 7	+ 70	− 59	+150	+173	− 62	+ 191
1900.......	+150	−134	−173	+ 26	+ 48	− 65	− 20	**+159**	+ 28	**+258**	− 25	+ 25	+ 277
1901.......	+ 72	−236	− 9	− 23	− 76	+ 83	**+152**	+ 13	− 11	+ 62	− 46	−164	− 183
1902.......	+ 47	−129	+130	+ 18	+ 74	− 62	+ 5	− 90	−112	+ 62	+234	− 88	+ 89
1903.......	+ 10	− 11	+177	+ 41	+ 98	**−153**	− 8	− 89	− 8	+ 16	− 81	−287	− 295
1904.......	−182	−242	+ 26	−157	+ 21	− 60	− 49	− 88	− 5	+ 5	+111	− 88	− 698
1905.......	−174	−248	+151	− 13	− 1	− 38	− 37	+ 87	+ 89	+ 2	+ 40	+ 78	− 64
1906.......	+276	+ 61	−126	+140	+ 99	+ 45	− 24	+134	+166	− 13	+ 77	+105	+ 940
1907.......	+129	+ 30	+255	−182	−155	− 7	+ 27	− 2	− 2	− 21	+ 56	+107	+ 235
1908.......	+152	+ 33	+195	+ 87	+ 66	+ 64	+ 59	+ 67	**+179**	+ 62	+125	+ 60	+1149
1909.......	+160	+196	+ 46	− 24	− 19	+ 7	− 3	+114	− 18	− 83	**+279**	−237	+ 418
1910.......	+ 62	− 20	**+440**	+159	− 98	+ 57	+113	+ 65	+ 19	+167	− 96	− 96	+ 772
1911.......	+168	+194	+152	+ 7	**+291**	**+183**	+114	+ 18	+ 70	+ 1	−109	+173	**+1262**
1912*......	**−368**	−113	−174	+ 91	+100	− 10	+ 16	− 5	+ 95	+ 77	+107	+127	− 57
1913*......	+176	− 14	+ 24	+ 86	+ 34	+125	+ 79	+ 97	+ 24	− 1	+238	+252	+1120
Means.....	±160	±140	±129	± 70	± 85	± 67	± 54	± 60	± 74	± 87	± 97	±143	± 522

Table III contains the monthly departures from normal temperature, expressed in degrees. Plus sign (+) indicates excess of temperature, above normal; minus sign (−) indicates deficiency of temperature, below normal. The extremes are shown by bold-faced type. The normal heat of each period is the sum of its daily normal temperatures (p. 33).

* Not included in means.

abnormal qualities greater than either April or June. This condition is due to proximity to the lake, whose influence is at its greatest in May, as will be brought out later, and causes changes of a wider range than during either the preceding or the following month.

The warmest years are easily 1911 and 1878, with accumulated departures of +1,262° and +1,211°, respectively, the mean temperatures being 52°.0 and 51°.9. In 1911 each month except November was above normal on the average, while in 1878 only eight months averaged above normal, although of the remaining four, three had but a slight deficiency. By far the coldest year is 1875, with an accumulated deficiency in temperature of 1,231°, and every month except December was below normal. The mean temperature of that year, 45°.1, compared with the mean of 1911, 52°.0, gives an absolute range in annual mean temperature of 6°.9. The years 1875 and 1878, however, are more strictly comparable, as the observations in both cases were made at the same location, the Major Block, and the difference between these two years is 6°.8. In fact, if the correction of 1°.7 were applied to the Federal Building record of 1911, as might properly be done, the average of that year would be reduced to 50°.3.

The average temperatures of the months having the greatest departures, together with the ranges, are as appear in Auxiliary Table B. Here again the great variability of the winter months is

AUXILIARY TABLE B

Month	Warmest		Coldest		Range
	Year	Degrees	Year	Degrees	Degrees
January	1880	39.8	1912	11.9	27.9
February	1882	39.0	1875	14.6	24.4
March	1910	48.6	1872	28.0	20.6
April	1896	53.4	1874	38.8	14.6
May	1911	65.9	1882	51.4	14.5
June	1911	72.4	1903	61.2	11.2
July	1901	77.4	1891	67.0	10.4
August	1900	76.3	1890	67.6	8.7
September	1908	70.6	1888	59.8	10.8
October	1900	61.4	1895	46.2	15.2
November	1909	48.5	*1872	31.6	16.9
December	1877	43.4	1872	18.4	25.0

*Also November, 1880.

brought out, January having the greatest absolute monthly range, 27°.9, with December and February following. The gradual change to smaller variability in summer is plainly evident here, as it is in the averages at the bottom of Table III, the absolute monthly range in August being only 8°.7. It is also interesting to note that the fluctuations experienced in May are almost as great as those of the preceding month of April.

Table IV brings out more vividly than is possible in Table III prolonged periods of excess or deficiency in temperature, as slight

reversions in periods of heat or cold are often lost in the accumulations through the entire year. In a study of this table it should be remembered that the accumulations for December are the accumulations for the year also, and the data appearing in the last column are

TABLE IV

YEARLY ACCUMULATED DEPARTURES BY MONTHS FROM NORMAL TEMPERATURES, EXPRESSED IN DEGREES, 1871–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Normal accumulated heat......	734	1445	2511	3887	5640	7630	9873	12081	14020	15670	16845	17754
1871........	+211	+387	+594	+ 738	+ 775	+ 811	+ 799	+ 815	+ 692	+ 577	+ 409	+ 142
1872........	− 28	− 31	−229	− 187	− 196	− 106	− 118	− 112	− 142	− 235	− 464	− 802
1873........	−127	−177	−241	− 332	− 469	− 410	− 521	− 523	− 583	− 693	− 844	− 760
1874........	+138	+282	+348	+ 148	+ 197	+ 318	+ 393	+ 445	+ 520	+ 534	+ 570	+ 679
1875........	−233	−**530**	−638	− **715**	− **774**	− **876**	− **991**	−**1088**	−**1199**	−**1360**	−**1438**	−**1231**
1876........	+276	+460	+446	+ 493	+ 585	+ 633	+ 689	+ 774	+ 692	+ 572	+ 586	+ 278
1877........	− 48	+284	+115	+ 134	+ 153	+ 173	+ 211	+ 230	+ 293	+ 365	+ 393	+ 829
1878........	+252	+564	+**897**	+**1090**	+1051	+1021	+1113	+1204	+1250	+1239	+**1381**	+1211
1879........	− 75	− 31	+160	+ 201	+ 241	+ 183	+ 285	+ 318	+ 214	+ 449	+ 550	+ 605
1880........	+**501**	+**766**	+888	+ 990	+**1249**	+**1378**	+**1405**	+**1452**	+**1399**	+**1343**	+1114	+ 951
1881........	−132	−141	−202	− 325	− 183	− 277	− 243	− 116	+ 36	+ 124	+ 149	+ 411
1882........	+154	+536	+695	+ 703	+ 547	+ 478	+ 364	+ 365	+ 374	+ 523	+ 623	+ 540
1883........	−227	−306	−377	− 347	− 457	− 514	− 566	− 669	− 792	− 825	− 737	− 685
1884........	−151	− 79	− 85	− 130	− 139	− 203	− 323	− 410	− 288	− 190	− 140	− 121
1885........	−151	−375	−470	− 463	− 563	+ 594	− 572	− 661	− 668	− 718	− 616	− 539
1886........	− 40	+ 96	+179	+ 295	+ 312	+ 312	+ 297	+ 340	+ 380	+ 491	+ 468	+ 344
1887........	−226	−212	−281	− 197	− 95	− 67	+ 29	− 54	− 123	− 308	− 389	− 470
1888........	−274	−360	−500	− 483	− 594	− 567	− 560	− 622	− 767	− 885	− 813	− 723
1889........	+164	− 1	+127	+ 159	+ 168	+ 46	− 12	− 31	− 89	− 209	− 228	+ 119
1890........	+223	+421	+267	+ 256	+ 157	+ 273	+ 264	+ 150	+ 24	− 34	+ 49	+ 85
1891........	+202	+296	+183	+ 218	+ 123	+ 104	− 65	− 133	− 4	− 23	− 190	− 4
1892........	−129	+ 7	− 97	− 152	− 278	− 336	− 360	− 373	− 393	− 382	− 516	− 698
1893........	−364	−472	−509	− 556	− 684	− 637	− 593	− 623	− 642	− 661	− 759	− 884
1894........	+119	+ 51	+266	+ 299	+ 288	+ 441	+ 471	+ 459	+ 503	+ 461	+ 315	+ 408
1895........	−191	−427	−509	− 502	− 422	− 312	− 380	− 342	− 221	− 438	− 518	− 512
1896........	+103	+133	+ 36	+ 262	+ 537	+ 557	+ 555	+ 603	+ 480	+ 363	+ 341	+ 457
1897........	− 54	+ 34	+ 43	+ 47	− 1	− 40	+ 17	− 53	+ 90	+ 248	+ 233	+ 101
1898........	+153	+214	+398	+ 353	+ 341	+ 413	+ 444	+ 454	+ 545	+ 468	+ 406	+ 251
1899........	− 27	−238	−383	− 259	− 181	− 74	− 81	− 11	− 70	+ 80	+ 253	+ 191
1900........	+150	+ 16	−157	− 131	− 83	− 148	− 168	− 9	+ 19	+ 277	+ 252	+ 277
1901........	+ 72	−164	−173	− 196	− 272	− 189	− 37	− 24	− 35	+ 27	− 19	− 183
1902........	+ 47	− 82	+ 48	+ 66	+ 140	+ 78	+ 83	− 7	− 119	− 57	+ 177	+ 89
1903........	+ 10	− 1	+176	+ 217	+ 315	+ 162	+ 154	+ 65	+ 57	+ 73	− 8	− 295
1904........	−182	−424	−398	− 555	− 534	− 594	− 643	− 731	− 736	− 731	− 620	− 708
1905........	−174	−422	−271	− 284	− 285	− 323	− 360	− 273	− 184	− 182	− 142	− 64
1906........	+276	+337	+211	+ 351	+ 450	+ 495	+ 471	+ 605	+ 771	+ 758	+ 835	+ 940
1907........	+129	+159	+414	+ 232	+ 77	+ 70	+ 97	+ 95	+ 93	+ 72	+ 128	+ 235
1908........	+152	+185	+380	+ 467	+ 533	+ 597	+ 656	+ 723	+ 902	+ 964	+1089	+1149
1909........	+160	+356	+402	+ 378	+ 359	+ 366	+ 363	+ 477	+ 459	+ 376	+ 655	+ 412
1910........	+ 62	+ 42	+482	+ 641	+ 543	+ 600	+ 713	+ 778	+ 797	+ 964	+ 868	+ 778
1911........	+168	+362	+514	+ 521	+ 812	+ 995	+1109	+1127	+1197	+1198	+1089	+**1262**
1912........	−**368**	−481	−**655**	− 564	− 464	− 474	− 458	− 463	− 368	− 291	− 184	− 57
1913........	+176	+162	+186	+ 272	+ 306	+ 431	+ 510	+ 607	+ 631	+ 630	+ 868	+1120

Table IV contains the accumulated departures from the normal temperature by months, expressed in degrees. Plus sign (+) indicates accumulated excess of temperature, above normal; minus sign (−) indicates accumulated deficiency of temperature, below normal. The extremes are shown by bold-faced type.

therefore identical with the annual values in Table III. The years 1875, 1878, 1880, 1906, 1908, 1911, and 1913 have the most pronounced accumulated departures, 1875 being a cold year and the remainder

warm years. At the end of the month of October, the year 1880 was warmer than either 1878 or 1911. The year 1878 was the warmest at the end of November, but because of a cold period in December, the annual mean was lower than that of 1911. The uniform excess in temperature in the six years from 1906 to 1911, inclusive, as shown in both Tables III and IV, is to a large extent due to the present exposure of the thermometers on the roof of the Federal Building, which, as has already been shown (p. 11), averages 1°.7 higher than the previous exposure at the Auditorium Tower. This average excess would amount to about 52° for the month, and 620°, nearly, for the year. Such correction would make the years 1907 and 1909 cold years instead of warm years, by deficiencies of 385° and 202°, respectively; and reduce 1908 and the record year of 1911 far below the warm years of 1878 and 1880 as recorded at the Major Block. Both the warm period of 1906 to 1911, and 1876 to 1880, inclusive, were broken somewhat by the occurrence of cold months here and there. There has been no other period than that of 1906 to 1911 where the accumulated departures continued above the normal for three successive years.

As regards cold periods, the most pronounced are those from January, 1883, to January, 1886, from July, 1891, to December, 1893, and from November, 1903, to December, 1905, the last two being less than three years in extent.

Space will not permit the discussion in detail at this time of the conditions of the warmest and coldest months, but a brief reference should nevertheless be made to certain of the most striking ones, and later more information will be given. The month of January, 1912, with its mean temperature of 11°.9, was not only the coldest of all months in the official records, but there were only two with lower temperature during the period of the unofficial records, January, 1857, 10°.7, and February, 1838, 11°.0. The period of cold in January, 1912, was continuous throughout the month, there being 13 days with minimum temperatures of zero or below, and the absolute minimum was −16°. The December of 1872 was also marked by a period of prolonged cold. On the 24th of that month a temperature of −23° occurred, the lowest minimum of official record in Chicago. The warmest July, that of 1901, 77°.4, was exceeded twice in mean temperature during the period of the old records, in 1846, 78°.0, and in 1868, 80°.6. In July, 1901, the highest absolute maximum temperature of the official record was reached, 103° on the 21st.

These data, as well as additional figures bearing on the warmest and coldest days in the various years, will be found in later tables (XXXIX to XLIV).

WARM AND COLD MONTHS AND SEASONS

It is easy to pick out the warmest and coldest months and seasons from the tables already given, but to list the months and seasons

TABLE V

WARM MONTHS AND SEASONS, 1871–1913

	Departure above Normal	
January	6°+	1871, 1876, 1878, 1880, 1890, 1891, 1906
February	6°+	1871, 1876, 1877, 1878, 1880, 1882, 1890, 1909, 1911
March	6°+	1871, 1878, 1879, 1894, 1898, 1903, 1907, 1908, 1910
April	5°+	1878, 1896, 1910
May	4°+	1880, 1881, 1896, 1911
June	4°+	1874, 1880, 1894, 1911, 1913
July	3°+	1879, 1901, 1910, 1911
August	3°+	1881, 1900, 1906, 1909, 1913
September	4°+	1881, 1884, 1891, 1895, 1897, 1906, 1908
October	4°+	1879, 1882, 1897, 1899, 1900, 1910
November	5°+	1899, 1902, 1909, 1913
December	6°+	1875, 1877, 1881, 1889, 1891, 1913
Winter	4°+	1873–74, 1875–76, 1877–78, 1879–80, 1881–82, 1889–90, 1905–6, 1908–9
Spring	3°+	1871, 1878, 1879, 1880, 1896, 1903, 1908, 1910, 1911
Summer	2°+	1874, 1876, 1880, 1901, 1908, 1910, 1911, 1913
Autumn	3°+	1881, 1884, 1897, 1908, 1912, 1913
Year (By seasons, beginning with previous December)	2°+	1878, 1880, 1882, 1906, 1908, 1911, 1913
Year (Calendar)	2°+	1870, 1877, 1878, 1880, 1906, 1908, 1910, 1911, 1913

TABLE VI

COLD MONTHS AND SEASONS, 1871–1913

	Departure below Normal	
January	6°+	1875, 1883, 1887, 1888, 1893, 1895, 1904, 1912
February	6°+	1875, 1885, 1895, 1899, 1901, 1904, 1905
March	6°+	1872
April	5°+	1874, 1904, 1907
May	4°+	1873, 1882, 1892, 1893, 1907
June	4°+	1889, 1903
July	3°+	1873, 1875, 1882, 1884, 1891
August	3°+	1875, 1883, 1890
September	4°+	1871, 1883, 1888, 1890, 1896
October	4°+	1875, 1887, 1888, 1895
November	5°+	1871, 1872, 1873, 1880, 1891
December	6°+	1871, 1872, 1876, 1903, 1909
Winter	4°+	1874–75, 1882–83, 1884–85, 1887–88, 1892–93, 1898–99 1903–4, 1904–5
Spring	3°+	1873, 1892
Summer	2°+	1875, 1883, 1884, 1889, 1891, 1903, 1904
Autumn	3°+	1871, 1872, 1873, 1875, 1880, 1887
Year (By seasons, beginning with previous December)	2°+	1873, 1875, 1883, 1888, 1893, 1904
Year (Calendar)	2°+	1872, 1873, 1875, 1888, 1893

TABLE VII

MEAN TEMPERATURE OF WARM AND COLD MONTHS, DURING PERIOD FROM 1871 TO 1913 COVERING DATA IN TABLES V AND VI

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Normal temperature	23.7	25.4	34.4	45.9	56.5	66.3	72.4	71.2	64.6	53.2	39.2	29.3
1871	**30.5**	**31.7**	**41.1**						60.5		33.6	20.7
1872			28.0								31.6	18.4
1873					52.1		68.8				34.2	
1874				38.8		**70.4**						
1875	16.1	14.6					68.8	67.9		48.1		**36.0**
1876	**32.8**	**31.9**										19.4
1877		**37.3**										**43.4**
1878	**31.8**	**36.4**	**45.2**	**52.4**								
1879			**40.6**				**75.6**			**60.8**		
1880	**39.8**	**34.8**			**65.0**	**70.6**					31.6	
1881					**61.0**			**75.4**	**70.2**			**37.7**
1882		**39.0**			51.4		68.8			**58.0**		
1883	16.4							67.8	60.6			
1884							68.6		**68.8**			
1885		17.8										
1886												
1887	16.4									47.2		
1888	14.8								59.8	49.1		
1889						62.3						**40.6**
1890	**30.8**	**32.4**						67.6	60.4			
1891	**30.2**						67.0		**69.0**		33.8	**35.4**
1892					52.4							
1893	12.0				52.4							
1894			**41.2**			**71.4**						
1895	17.6	17.0							**68.6**	46.2		
1896				**53.4**	**65.5**				60.6			
1897									**69.5**	**58.4**		
1898			**40.4**									
1899		17.9								**58.0**	**44.8**	
1900								**76.3**		**61.4**		
1901		17.0					**77.4**					
1902											**47.0**	
1903			**40.4**			61.2						20.0
1904	17.7	17.2		40.7								
1905		17.0										
1906	**32.6**							**75.6**	**70.1**			
1907			**42.6**	39.8	51.6							
1908			**40.6**						**70.6**			
1909		**32.4**						**74.8**			**48.5**	21.6
1910			**48.6**	**51.2**			**76.0**			**58.6**		
1911		**32.4**			**65.9**	**72.4**	**76.0**					
1912	11.9											
1913						**70.5**		**74.3**			**47.2**	**37.4**

Warm months in bold-faced type.

which can properly be characterized as warm or cold requires first the determination of what shall define a warm month, a cold month, a warm season, and a cold season. The mean departures shown in Table III would indicate that greater ranges occur in the winter months, and therefore that a warm or cold winter month must vary from its normal by considerably more than should a warm or cold summer month. Allowing for the number of days in the month, these departures average about 5° from December to March, inclusive, and about 2° for July and August. By adding an extra degree beyond the limit of which the monthly values will designate warm and cold months, and sliding the scale uniformly throughout the

year, we have as the limits for December, January, February, and March, 6°; April and November, 5°; May, June, September, and October, 4°; and July and August, 3°. As cold and warmth are not so frequently protracted through seasons and years, a reduction must be made from these limits, and the following were adopted: winter, 4°; spring and autumn, 3°; summer, 2°; the year, 2°. On this basis the list of warm and cold months, seasons, and years was made up, and the data are presented in Tables V and VI. The same data for the months are entered in Table VII, for some purposes a more usable form, as the actual mean temperatures for the warm and cold months are entered in their proper places.

In Table VIII are given the warmest and coldest seasons and years with the ranges between the extreme mean temperatures in each case. The principal feature brought out in this table is the great range between the warmest and coldest winters, 18°.9, as compared with the small range for the other seasons, and the year as a whole. The mean annual temperature of 53°.0 in 1846 exceeded that shown in the table by 1°.0, while there are several years in the old record with a lower mean than 45°.1.

TABLE VIII

Warmest and Coldest Seasons and Years, 1871–1913

	Winter	Spring	Summer	Autumn	Year
Normal temperature	26.1	45.6	70.0	52.3	48.5
Warmest	37.2	51.1	73.4	56.4	52.0
Departure	+11.1	+ 5.5	+ 3.4	+ 4.1	+ 3.5
Year	1877–78	1910	1911	1908	1911
Coldest	18.3	42.4	66.6	48.5	45.1
Departure	− 7.8	− 3.2	− 3.4	− 3.8	− 3.4
Year	1903–4	1873	1875	1872 (1875)	1875
Range	18.9	8.7	6.8	7.9	6.9

The winter of 1877–78 and the spring of 1910 are the warmest on record for these seasons, not excluding the entire period of unofficial record, and there are only two winters during that time of lower mean temperature than that of 1903–4 shown in the table: 1831–32, 18°.0, and 1855–56, 17°.3. Several spring seasons in the early days were colder than the spring of 1873. The means of the summers of 1867, 1868, and 1870 nearly equal that of 1911, and it is unfortunate that the daily maximum temperatures for those seasons are not available. Also, there are several summers in the old records that are colder than that of 1875, and several autumns colder than

those of 1872 and 1875, but the mean of the latter season in 1908 is higher than that of any autumn in the old records. These comparisons cover the entire period of record from 1830 to 1913, as given in Table I, although, as previously shown, exact comparisons are not possible owing to the conditions under which the data prior to 1871 were obtained.

SUCCESSION OF SEASONS, MONTHS, AND YEARS

There are many maxims to the effect that pronounced seasonal conditions govern or indicate the character of the following seasons or year. Table IX was prepared for the purpose of determining

TABLE IX

SUCCESSION OF SEASONS, 1872–1910

	Total Number	Spring (±1.5+)			Summer (±1.0+)			Autumn (±1.5+)			Winter (±2.0+)		
		Cold	Ave.	Warm	Cold	Ave.	Warm	Cold	Ave.	Warm	Cold	Ave.	Warm
Normal **26.1**			**45.6**			**70.0**			**52.3**			**26.1**	
Cold winters (−2.0+)	15	6	6	3	4	9	2	5	6	4	2	7	6
Warm winters (+2.0+)	12	3	6	3	2	3	7	3	4	5	6	1	5
No. with departure less than 2.0	12												
		Autumn (±1.5+)			Winter (±2.0+)			Spring (±1.5+)			Summer (±1.0+)		
		Cold	Ave.	Warm	Cold	Ave.	Warm	Cold	Ave.	Warm	Cold	Ave.	Warm
Normal **70.0**			**52.3**			**26.1**			**45.6**			**70.0**	
Cold summers (−1.0+)	11	3	5	3	5	3	3	5	4	2	4	6	1
Warm summers (+1.0+)	12	2	5	5	7	2	3	1	7	4	2	6	4
		Year											
Normal **48.5**													
Cold years (−1.0+)	11	3	5	3									
Warm years (+1.0+)	13	3	2	8									
No. with departure less than 1.0	15												

whether there is any uniformity in the succession of warm and cold seasons and years, and a careful examination fails to afford any clue by which the nature of a season or year may be foretold from any of its predecessors. Out of 15 cold winters, only 2 were followed by cold winters in the ensuing year, while only 6 were followed by warm winters. Of the 12 warm winters, 6 were followed by cold, and 5 by warm winters. The same irregularity is evident in the character of

the other seasons of the year succeeding these cold and warm winters, and also in the character of any of the seasons following the cold and warm summers. This may also be said regarding the succession of the years, although, as pointed out in the discussion of Table IV, years warmer than the normal have followed each other in two marked instances of several years' duration.

Reference to Tables I and III will show that there is no more uniformity in the succession of months of given character than there is in that of seasons or years. There have been several years in which the months have been successively above or below the normal temperature, while in other instances warm months are followed by cold months, and vice versa. It is often said that Nature tends to average up, but the average of temperature may be made in a month, less frequently in a season, and it is seldom spread evenly over the extent of a year or two years. For instance, the warm period beginning in the summer of 1906 continued through March, 1907, but was followed by such cold weather that the accumulated departures were reduced to nearly normal conditions by June 1. This March, in fact, was the second warmest on record up to that year, and caused an unseasonably early start in all kinds of vegetation. The succeeding months of April and May were marked by abnormal cold and severe frosts that did much damage in the fruit sections of the entire Middle West. The mean of April of this year, 39°.8, was below that of March, 42°.6, by 2°.8, a phenomenal occurrence when it is considered that the normal for April is 11°.5 higher than the normal for March. March, 1910, was even warmer than the same month in 1907, but the warmth continued through the first half of April, a cold wave appearing on the 22d, with snow and severe frosts on the ensuing days, which caused damage similar to that in the spring of 1907.

The high mean temperature of March, 1907, may be contrasted with that of the same month in 1906, 42°.6 and 30°.2, respectively, the latter being lower than that of the preceding January, 32°.6. In 1877, March, with mean temperature of 28°.9, followed a warm February with an average of 37°.3. This is the most startling instance of reversion of temperature to be found in the record, the mean of this March being actually 8°.4 lower than that of the preceding February, when under normal conditions for both months it should be 9°.0 higher. It is interesting to note that the greatest of the three instances of reversion of temperature in the fall and winter months also

occurred in 1877, the warm December of that year, 43°.4, being higher by 3°.4 than November, which was of nearly normal character. Following a cool period in 1889 from June to November, the temperature of the three succeeding months was considerably above the average, the mean for December exceeding that for November by 2°.0. In 1891 the average for December was higher than that for November by 1°.6. In the study of these various records one is ever impressed with the irregularities in temperature, but only in the few instances given above do we find in the march of temperature throughout the year a spring month to average lower, or an autumn month to average higher, than its predecessor.

MEAN DAILY TEMPERATURES

Tables X, XI, and XII give the average daily maximum, average daily minimum, and average daily mean temperatures for each day of the year, as determined from the period 1872 to 1910, inclusive,

TABLE X

Mean Daily Maximum Temperatures, 1872–1910

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	34.3	29.1	38.2	47.6	57.7	66.8	78.2	78.0	76.6	65.8	54.6	36.7
2	32.1	29.6	38.9	46.7	58.0	66.8	78.7	77.8	76.6	67.7	53.7	37.4
3	30.6	28.8	37.1	49.3	60.1	70.6	79.9	78.9	75.4	67.8	52.7	38.1
4	30.6	28.5	35.4	50.5	58.6	72.7	77.9	77.7	74.7	64.1	53.3	37.5
5	30.8	30.3	38.3	50.2	61.6	70.9	78.3	79.1	75.3	63.6	51.8	38.3
6	29.6	31.6	41.2	52.0	59.0	71.1	79.4	78.2	76.2	62.3	51.4	38.8
7	31.8	32.9	39.9	49.1	60.2	71.9	79.5	79.5	75.7	64.5	51.9	35.6
8	32.5	31.5	41.1	49.6	64.3	70.6	79.0	80.6	74.3	64.1	49.6	36.5
9	30.0	30.9	43.4	50.5	65.5	70.3	79.3	81.0	74.4	63.6	49.8	36.2
10	29.7	32.6	43.8	50.5	65.6	70.8	78.7	78.8	73.3	63.9	48.5	37.2
11	30.3	34.1	43.4	51.9	63.9	72.3	79.5	78.3	73.3	61.1	49.4	37.3
12	31.7	33.2	39.9	52.7	65.9	73.3	81.4	77.7	71.9	59.8	47.5	38.2
13	30.1	34.2	40.4	53.5	62.4	75.0	79.8	77.6	69.3	61.3	46.5	37.0
14	29.1	34.1	38.4	53.3	62.0	74.6	80.7	77.6	72.5	61.4	44.0	35.7
15	32.1	32.7	39.3	53.1	62.5	75.3	81.3	75.1	74.1	63.4	45.3	35.3
16	32.1	32.8	40.1	52.3	63.7	74.1	82.2	76.9	72.2	62.7	45.6	35.0
17	32.9	35.6	41.4	53.8	66.4	75.7	81.0	77.1	71.6	61.2	45.8	32.5
18	31.1	34.1	44.4	56.2	66.2	76.2	77.2	78.8	71.6	59.4	43.4	32.7
19	32.8	33.3	42.4	53.0	65.8	75.9	78.4	77.6	69.8	59.2	42.6	33.7
20	34.5	33.3	39.8	54.6	64.4	76.1	77.7	79.6	68.8	56.9	44.4	35.5
21	33.9	33.7	42.9	54.9	64.2	74.8	79.1	79.0	71.5	58.5	44.9	35.9
22	31.9	34.4	44.4	57.7	67.6	75.6	79.9	78.0	70.4	58.3	44.4	35.8
23	29.8	31.8	45.8	56.5	65.7	78.1	78.1	77.7	69.8	56.9	43.3	35.7
24	29.9	34.6	43.8	54.9	68.2	78.6	80.1	77.6	69.7	56.4	39.9	34.2
25	30.9	34.3	46.0	54.8	67.2	78.3	81.1	76.2	69.3	56.8	41.7	32.4
26	31.6	35.3	47.9	57.8	66.3	76.1	80.4	74.9	68.9	56.3	42.4	32.3
27	29.5	35.7	46.3	60.0	66.6	76.1	79.6	75.5	67.0	52.6	40.9	34.1
28	30.7	37.2	42.4	61.5	67.4	76.5	80.5	77.4	65.7	54.2	37.7	32.3
29	31.1	31.2	45.8	60.3	69.3	77.4	79.1	76.2	66.1	54.3	35.5	34.5
30	31.7	......	45.3	58.5	67.4	77.3	79.1	76.3	65.8	53.6	33.4	33.1
31	30.0	......	47.1	......	67.4	......	77.9	75.7	......	53.4	......	31.9
Means	31.3	32.7	42.1	53.6	64.3	74.0	79.4	77.7	71.7	60.2	45.9	35.5
Mean annual maximum, 55°.7												

Table X contains the mean daily maximum temperature based upon readings of the maximum thermometer from 1872 to 1910. The value for each day is found by adding all the maximums on that date together, and dividing by the number of years, 39.

and Fig. 4 presents the same data so as to illustrate the daily march of temperature throughout the year. On the average the lowest minimum, 13°8, occurs on February 1, and the highest maximum, 82°2, on July 16. Similarly the lowest daily mean temperature, 21°2, and the highest daily mean temperature, 74°6, occur respectively on these same dates. This is also true of the highest mean minimum temperature, 66°9, which falls on July 16; but the lowest

TABLE XI

MEAN DAILY MINIMUM TEMPERATURES, 1872–1910

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	20.2	13.8	25.5	33.7	42.6	53.2	63.7	66.2	63.0	52.3	39.8	24.6
2	17.8	14.2	26.0	33.0	41.9	53.2	64.3	65.6	61.9	53.3	39.6	25.8
3	16.1	16.2	24.7	34.6	43.7	54.4	64.4	65.1	61.8	53.6	37.7	26.6
4	15.9	14.1	23.1	35.1	45.1	55.6	64.6	65.5	61.7	51.5	39.4	25.1
5	16.7	14.3	25.8	35.7	45.9	55.3	63.7	65.7	61.5	50.9	38.3	24.9
6	17.3	16.2	26.8	35.6	45.8	55.2	64.3	65.1	61.8	49.6	36.5	24.0
7	17.3	19.4	27.5	35.9	45.9	55.5	64.2	65.7	61.6	49.5	38.3	23.1
8	17.7	18.0	28.1	35.9	47.3	56.5	65.9	66.6	61.2	49.2	38.4	23.7
9	14.9	16.6	29.6	37.0	48.8	55.4	65.0	65.9	61.2	49.5	37.5	22.9
10	15.2	18.1	29.1	37.1	49.5	55.1	64.5	65.3	60.1	48.9	37.2	24.2
11	16.6	18.9	28.6	37.3	48.7	56.9	64.3	65.1	59.4	48.6	35.9	25.2
12	16.3	18.4	27.7	38.7	49.3	57.9	65.3	65.3	60.0	47.5	33.5	24.8
13	16.0	18.3	27.3	38.6	48.1	59.3	65.6	65.2	57.5	46.8	31.9	24.6
14	16.1	19.1	25.2	39.6	46.8	59.7	66.0	65.2	57.7	46.5	31.8	22.9
15	18.9	18.7	25.7	38.5	46.9	60.3	66.5	64.9	58.0	48.5	32.3	22.1
16	17.9	17.4	25.7	37.9	47.6	59.8	66.9	64.5	57.1	47.4	32.6	21.3
17	16.8	19.6	26.5	39.0	50.3	60.4	66.5	64.8	56.7	46.6	32.5	21.2
18	19.6	19.9	29.2	41.7	50.5	60.3	64.8	65.6	56.9	45.3	31.4	19.9
19	17.5	20.2	30.4	40.2	50.7	61.2	64.5	65.9	56.8	44.2	30.4	21.1
20	19.8	19.2	26.9	39.6	50.1	60.9	64.9	64.7	55.1	43.8	31.2	22.7
21	19.4	19.6	28.1	40.9	50.1	60.8	64.6	65.4	55.1	44.3	31.6	24.0
22	18.5	19.3	29.5	42.2	50.3	60.5	65.6	64.9	56.5	44.4	30.6	22.9
23	16.3	19.9	30.1	41.6	51.3	62.6	65.3	63.9	55.9	42.9	28.6	22.8
24	14.6	20.0	30.8	40.9	51.2	63.2	66.2	64.3	56.0	42.7	27.7	21.0
25	15.8	20.3	31.2	41.4	52.4	63.4	66.7	63.4	55.4	42.6	29.0	21.4
26	18.3	21.4	32.4	42.9	50.6	62.8	66.9	63.2	54.0	43.2	29.6	20.0
27	17.6	21.8	32.8	44.3	51.1	62.9	66.3	63.2	52.5	40.7	26.8	19.5
28	15.9	23.9	31.6	45.3	51.5	62.6	66.7	64.6	54.1	39.9	24.9	19.5
29	15.7	21.8	31.7	44.3	52.6	62.9	66.1	64.1	53.4	40.6	22.8	20.2
30	15.4	......	32.8	41.9	52.3	63.9	66.0	64.0	52.0	40.9	22.9	19.6
31	16.1	......	34.4	......	52.1	......	66.5	63.9	......	40.4	......	19.7
Means	17.0	18.5	28.5	39.0	48.7	59.0	65.4	65.0	57.9	46.3	32.7	22.6
Mean annual minimum, 41°7												

Table XI contains the mean daily minimum temperature based upon the readings of the minimum thermometer from 1872 to 1910. The value for each day is found by adding all the minimums on that date together and dividing by the number of years, 39.

mean maximum temperature, 28°5, occurs on February 4. The average highest minimum is seen in the table to occur on July 26, as well, but on the average, February 1 and July 16 are the dates of highest and lowest temperatures. The temperature therefore rises throughout 165 days of the year, and falls throughout 200 days. It is interesting to note in this connection that at Baltimore, 2° 35′ farther south in latitude, the period of rise is 4 days shorter, from

February 5 to July 16, and the period of fall 4 days longer (*Maryland Weather Service*, II, 78). The change from the lowest temperature of winter to the highest of summer and back again is not a steady march, the advance and retreat of the seasons being accomplished by a succession of waves of rising and falling temperature of unequal periods, but averaging from three to four days each, accompanying the movement across the country of areas of high and low barometric pressure with their attendant shifting winds.

TABLE XII

MEAN DAILY TEMPERATURES, 1872–1910

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	27.6	21.2	31.8	40.6	50.2	60.0	70.8	72.3	69.9	58.8	47.2	30.7
2	24.9	21.9	32.5	39.8	50.5	60.8	71.5	71.6	69.2	60.5	46.7	31.5
3	23.3	22.6	31.1	42.0	51.7	60.5	72.1	71.8	68.6	60.7	45.2	32.5
4	23.2	21.3	29.0	42.8	52.0	64.1	71.3	71.7	68.0	57.7	46.3	31.2
5	24.0	22.3	32.0	43.0	53.7	63.1	71.3	72.5	68.4	57.2	45.2	31.5
6	23.4	25.2	33.9	43.8	53.2	63.1	71.9	71.9	68.9	55.8	43.9	31.3
7	24.5	26.2	33.7	42.9	52.9	63.7	71.9	72.5	68.7	57.0	44.0	29.5
8	25.0	24.8	34.6	42.8	55.8	63.5	72.4	73.7	67.7	56.6	44.0	30.1
9	25.0	23.8	36.4	43.7	57.0	62.9	72.1	73.3	67.8	56.5	43.7	29.6
10	22.4	25.3	36.5	43.9	57.7	63.0	71.6	71.6	66.7	56.2	42.8	30.8
11	23.4	26.4	36.0	44.6	56.2	64.7	71.8	71.9	66.2	54.9	42.6	29.7
12	23.9	25.8	33.7	45.7	57.6	65.5	73.3	71.6	65.9	53.4	40.6	31.6
13	23.3	26.2	34.1	46.0	55.3	67.2	72.7	71.4	63.4	54.1	39.1	30.8
14	22.6	26.5	31.8	46.4	54.5	67.4	73.3	71.2	64.6	54.0	38.0	29.2
15	25.5	25.8	32.6	45.8	54.7	67.7	73.8	69.8	66.0	55.5	38.7	28.7
16	24.9	25.0	32.9	45.1	55.7	67.1	74.6	70.6	64.6	55.1	39.1	28.2
17	24.8	26.3	33.9	46.4	58.4	67.8	73.7	70.9	64.1	53.9	39.0	26.8
18	25.4	27.0	36.8	48.9	58.4	67.9	71.0	72.3	64.3	52.4	37.4	26.4
19	25.2	26.7	36.4	46.5	58.2	68.2	71.5	71.7	63.3	51.7	36.5	27.1
20	27.4	26.2	33.5	47.1	57.3	68.1	71.3	72.3	61.9	50.4	37.6	29.1
21	26.6	26.7	35.5	48.3	57.2	67.8	71.8	72.2	63.3	51.4	37.5	30.0
22	25.2	26.9	37.0	49.8	58.9	68.1	72.7	71.3	63.5	51.3	37.5	29.4
23	23.1	25.9	37.9	48.8	58.5	70.5	71.7	70.9	62.8	49.9	35.9	29.3
24	22.2	27.3	37.3	47.9	59.7	71.0	73.1	70.9	62.7	49.6	33.8	27.5
25	23.4	27.3	38.6	48.1	59.8	70.8	73.9	69.7	62.3	49.7	35.3	26.8
26	23.7	28.3	40.2	50.3	58.4	69.3	73.6	69.0	61.5	49.8	36.1	26.2
27	23.6	28.8	39.5	52.2	58.9	69.4	72.9	69.4	59.8	46.6	33.9	26.8
28	26.0	30.4	37.0	53.3	59.4	69.2	73.7	70.8	60.0	47.1	31.3	25.9
29	23.4	......	36.1	52.4	61.1	69.8	72.5	70.2	59.7	47.5	29.3	24.7
30	23.6	......	39.2	50.2	59.9	69.0	72.5	70.0	58.8	46.9	29.3	26.4
31	23.1	......	40.4	......	59.8	......	72.1	70.1	......	46.9	......	27.0
Means	24.1	25.6	35.3	46.3	56.5	66.5	72.4	71.4	64.8	50.7	39.3	29.1
Mean annual mean, 48°.7												

Table XII contains the daily mean temperature—the mean of the maximum and the minimum—from 1872 to 1910. The value for each day is found by adding all the mean temperatures on that date together and dividing by the number of years, 39. The mean daily temperature thus obtained is about one-half degree higher than the mean of the 24 hourly readings. The annual mean temperature shown above, 48°.7, is lower by 0°.1 than the annual mean shown in Table I, the period in the latter table being one year longer.

It will be noticed that the highest and lowest mean temperatures do not occur at the times of the solstices, June 21 and December 21, when the northern hemisphere receives the maximum and minimum amount of heat from the sun, respectively, but lag behind these times by more than three weeks in summer and five weeks in winter.

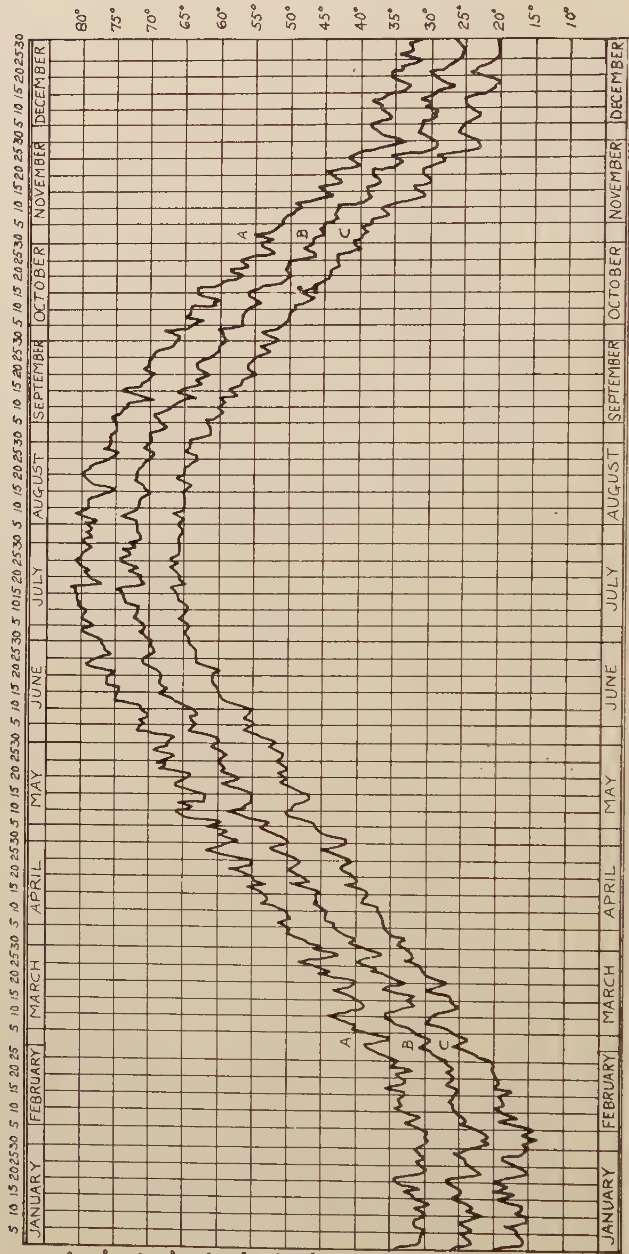


FIG. 4.—Daily march of temperature.

A = average daily maximum temperature; B = daily mean temperature; C = average daily minimum temperature.

The atmosphere and earth are storing heat so long as the daily quantity received exceeds the loss by radiation, and as a consequence the time of maximum temperature is delayed until these two factors are equal. Similarly, there will be loss of heat during the winter so long as the daily amount of radiation from a given region exceeds the daily solar insolation, and the time of minimum temperature is delayed until the returning sun furnishes daily a sufficient amount of heat to balance or exceed that lost from the region in question. It will be evident that the maximum temperature of summer, July 16, occurs relatively earlier after the solstice than does the minimum temperature of winter, February 1; or, in other words, that the mean temperature rises through a shorter period than it falls, as stated in a previous paragraph. Other things being equal, these periods should be of the same length, and the times of highest and lowest temperatures should follow the solstices at the same interval, so that there must be some disturbing influence which retards the occurrence of the minimum temperature, or accelerates the occurrence of the maximum, or both. Von Bezold divides the earth into three zones, an equatorial zone in which insolation is considerably greater than radiation, and two polar zones in which the amount of radiation is greater than the amount of insolation (*Mechanics of the Earth's Atmosphere*, 3d Collection—Abbe, p. 388), and fixes the boundaries at between 35° and 40° of latitude. Plainly the equatorial or insolation zone would be marked by higher and higher temperatures each year, and the polar or radiation zones by temperatures becoming lower and lower, were it not that the excess of heat in the one is transferred by convection (circulation) to the two radiation zones, thus maintaining the mean annual temperature. Chicago is situated just within the north radiation zone, and this fact explains why the minimum temperature of winter is retarded to a seemingly undue extent; and also why the period of excess heat in summer is shortened, thereby advancing the time of maximum temperature.

Table X shows that the maximum temperature in June averages 74°.0, in July 79°.4, in August 77°.7, and in September 71°.7. The average maximum in January is 31°.3, and this is the only month in which the maximum temperature averages below freezing. Table XI shows that the minimum temperature averages in January 17°.0, in February 18°.5, in March 28°.5, in November 32°.7, and in December 22°.6. The mean daily maximum for the entire year is 55°.7, and the mean daily minimum 41°.7. These values, however, do not express

much in themselves, but they serve to establish the mean daily range for the year, 14°0.

MEAN DAILY CHANGE IN TEMPERATURE

The figures in Table XIII show the mean changes in temperature from day to day throughout the year. They are obtained from

TABLE XIII

MEAN DAILY CHANGE IN TEMPERATURE, EXPRESSED IN DEGREES AND TENTHS OF A DEGREE, 1873–1910

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	+0.6	−1.9	+1.4	+0.2	0	+0.2	+1.8	+0.2	−0.2	0	+0.3	+1.4
2	−2.7	+0.7	+0.7	−0.8	+0.3	+0.8	+0.7	−0.7	−0.7	+1.7	−0.5	+0.8
3	−1.6	+0.7	−1.4	+2.2	+1.2	−0.3	+0.6	+0.2	−0.6	+0.2	−1.5	+1.0
4	−0.1	−1.3	−2.1	+0.8	+0.3	+3.6	−0.8	−0.1	−0.6	−3.0	+1.1	−1.3
5	+0.8	+1.0	+3.0	+0.2	+1.7	−1.0	0	+0.8	+0.4	−0.5	−1.1	+0.3
6	−0.6	+2.9	+1.9	+0.8	−0.5	0	+0.6	−0.6	+0.5	−1.4	−1.3	−0.2
7	+1.1	+1.0	−0.2	−1.2	−0.3	+0.6	0	+0.6	−0.2	+1.2	+0.1	−2.0
8	+0.5	−1.4	+0.9	+0.2	+2.9	−0.2	+0.5	+1.2	−1.0	−0.4	0	+0.8
9	0	−1.0	+1.8	+0.9	+1.2	−0.6	−0.3	−0.4	+0.1	−0.1	−0.3	−0.5
10	−2.6	+1.5	+0.1	+0.2	+0.7	+0.1	−0.5	−1.7	−1.1	−0.3	−0.9	+1.2
11	+1.0	+1.1	−0.5	+0.7	−0.8	+1.7	+0.2	+0.3	−0.5	−1.3	−0.2	−1.1
12	+0.5	−0.6	−2.3	+1.1	+1.4	+0.8	+1.5	−0.3	−0.3	−1.5	−2.0	+1.9
13	−0.6	+0.4	+0.4	+0.3	−2.3	+1.7	−0.6	−0.2	−2.5	+0.7	−1.5	−0.8
14	−0.7	+0.3	−2.3	+0.4	−0.8	+0.2	+0.6	−0.2	+1.2	−0.1	−1.0	−1.6
15	+2.9	−0.7	+0.8	−0.6	+0.2	+0.3	+0.2	−1.4	+1.4	+1.5	+0.7	−0.5
16	−0.6	−0.8	+0.3	−0.7	+1.0	−0.6	+0.8	+0.8	−1.4	−0.4	+0.4	−0.5
17	−0.1	+1.3	+1.0	+1.3	+2.7	+0.7	−0.9	+0.3	−0.5	−1.2	−0.1	−1.4
18	+0.6	+0.7	+2.9	+2.5	0	+0.1	−2.7	+1.4	+0.2	−1.5	−1.6	−0.4
19	−0.2	−0.3	−0.4	−2.4	−0.2	+0.3	+0.5	−0.6	−1.0	−0.7	−0.9	+0.7
20	+2.2	−0.5	−2.9	+0.6	−0.9	−0.1	−0.2	+0.6	−1.4	−1.3	+1.1	+2.0
21	−0.8	+0.5	+2.0	+1.2	−0.1	−0.3	+0.5	−0.1	+1.4	+1.0	−0.1	+0.9
22	−1.4	+0.2	+1.5	+1.5	+1.7	+0.3	+0.9	−0.9	+0.2	−0.1	0	−0.6
23	−2.1	−1.0	+0.9	−1.0	−0.4	+2.4	−1.0	−0.4	−0.7	−1.4	−1.6	−0.1
24	−0.9	+1.4	−0.6	−0.9	+1.2	+0.5	+1.4	0	−0.1	−0.3	−2.1	−1.8
25	+1.2	0	+1.3	+0.2	+0.1	−0.2	−0.8	−1.2	−0.4	+0.1	+1.5	−0.7
26	+0.3	+1.0	+1.6	+2.2	−1.4	−1.5	−0.3	−0.7	−0.8	+0.1	+0.8	−0.6
27	−0.1	+0.5	−0.7	+1.9	+0.5	+0.1	−0.7	+0.4	−1.7	−3.2	−2.2	+0.6
28	+2.4	+1.6	−2.5	+1.1	+0.5	−0.2	+0.8	+1.4	+0.2	+0.5	−2.6	−0.9
29	−2.6	......	−0.9	−0.9	+1.7	+0.6	+1.2	−0.6	−0.3	+0.4	−2.0	−1.2
30	+0.2	......	+3.1	−2.2	−1.2	−0.8	0	−0.2	−0.8	−0.6	0	+1.7
31	−0.5	......	+1.2	......	−0.1	......	−0.4	+0.1	......	0	......	+0.6
Means	±1.0	±0.9	±1.4	±1.0	±0.9	±0.7	±0.7	±0.6	±0.7	±0.9	±1.0	±1.0

Table XIII contains the mean change in daily temperature, that is, the variations, plus or minus, between the means of succeeding days.

SUMMARY OF TABLE XIII

MEAN DAILY CHANGE IN TEMPERATURE

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average daily change	±1.0	±0.9	±1.4	±1.0	±0.9	±0.7	±0.7	±0.6	±0.7	±0.9	±1.0	±1.0
Average number of positive changes	13	17	19	21	17	18	17	13	9	10	8	13
Average amount of positive changes (degrees)	1.1	0.9	1.4	1.0	1.1	0.8	0.8	0.6	0.6	0.7	0.8	1.1
Average number of negative changes	17	10	12	9	12	11	11	17	21	19	19	18
Average amount of negative changes (degrees)	1.1	1.0	1.4	1.2	0.8	0.5	0.8	0.6	0.8	1.0	1.2	0.9
Average number of times with no change	1	1	0	0	2	1	3	1	0	2	3	0

Table XII by taking the differences as they occur, from each day to the following. The much greater variability of temperatures in winter has already been brought out (p. 15), and we should therefore expect these daily changes to be greater in that season. While this is true on the average, the extreme values of mean change occur at some other time: the greatest of either positive or negative changes on June 4, +3°6, and the greatest negative change on October 27, −3°2. There is, of course, the greatest number of positive changes, or days warmer than the one immediately preceding, from midwinter to midsummer; and the greatest number of negative changes, or days cooler than the one immediately preceding, from midsummer to midwinter. This follows naturally from the succession of the seasons, but is by no means absolutely uniform, as an inspection of the table or of the graph in Fig. 4 will show. The greatest number of changes to warmer in any month, 21, occurs in April, with an average of 1°0 for each change; while the least number of changes to cooler, 9, also occurs in April, with an average of 1°9 for each change. September holds the record for the greatest number of changes to cooler, 21, with an average of 0°8 for each, and the least number of changes to warmer, 9, with an average of 0°6 each.

FREQUENCY OF CHANGES OF STATED AMOUNTS IN MEAN DAILY TEMPERATURE

It is important to know the average frequency of changes of certain amounts in mean temperature from one day to the next, and for this purpose Table XIV is given. It is a summary of extensive data for which there is hardly room in this bulletin, and adds interesting confirmation to the statements made in connection with Tables III and XIII, regarding the greater variations in temperature occurring during the winter than is the case during the summer. It will readily be seen that there are but few instances during the warm months where a change of 15° or more between the mean temperatures of two successive days has occurred. The number of such changes is least in August, when on the average one occurs in ten years, and greatest in January and February, when they average more than two for each month. In the case of the smaller changes of from 0° to 5°, the conditions are reversed, because by far the larger proportion of the daily changes in the summer season are of this kind, while in January, for instance, more than one-half of all the daily changes are of 6° or more. All portions of the table *a*, *b*, and *c* show this to

be true, and all emphasize the great irregularity in temperature change, especially the last two sections, in that some months show 20 days or more on which the temperature change exceeds 6°, while in other months, even in colder weather, marked changes are comparatively few. A striking example is that of November, 1878, in which there was only one change of 6° or more during the entire month, while in August, 1901, there was not a single instance of such a change. It should be understood that the diurnal changes

TABLE XIV

(*a*) Average Number of Changes in Daily Mean Temperature of Stated Amounts, 1873–1910

Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Change of 0° to 5°, incl.	14.6	13.6	17.2	16.0	17.8	18.6	21.5	23.1	19.8	18.8	17.8	17.0
Change of 6° plus....	16.4	14.7	13.8	14.0	13.2	11.4	9.5	7.9	10.2	12.2	12.2	14.0
Change of 10° plus....	8.7	7.1	6.4	6.4	6.0	4.3	1.9	1.3	3.4	4.4	4.7	6.6
Change of 15° plus....	2.9	2.3	1.6	1.7	1.2	0.6	0.2	0.1	0.5	0.8	1.2	2.0

(*b*) Examples of Greatest Diurnal Changes in Temperature

Year and Month	Jan. 1875	Feb. 1888	Mar. 1888	April 1910	May 1907	June 1891	July 1874	Aug. 1888	Sept. 1873	Oct. 1895	Nov. 1894	Dec. 1893
Change of 0° to 5°, incl.	9	9	13	14	16	18	13	19	16	15	10	8
Change of 6° plus....	22	20	18	16	15	12	18	12	14	16	20	23
Change of 10° plus....	14	10	12	10	10	6	6	3	8	7	11	16
Change of 15° plus....	8	5	4	8	4	3	1	2	3	3	5	7

(*c*) Examples of Least Diurnal Changes in Temperature

Year and Month	Jan. 1891	Feb. 1897	Mar. 1881	April 1881	May 1877	June 1907	July 1882	Aug. 1901	Sept. 1877	Oct. 1882	Nov. 1878	Dec. 1896
Change of 0° to 5°, incl.	23	22	25	25	25	24	28	31	26	25	29	23
Change of 6° plus....	8	6	6	5	6	6	3	0	4	6	1	8
Change of 10° plus....	1	2	1	0	3	2	1	0	0	1	0	2
Change of 15° plus....	1	1	0	0	0	0	0	0	0	0	0	0

referred to in Tables XIII and XIV are merely the differences in mean daily temperature between two successive days, and that they have nothing to do with daily range in temperature, which will be discussed later. In order to comprehend properly Table XIV, the reader should bear in mind that the sum of the number of changes from 0° to 5°, and the number of changes of 6°+, in every case equals the total number of days in the month; and that the changes of 6°+ include those of 10°+ and 15°+, and that the changes of 10°+ include those of 15°+.

DAILY NORMAL TEMPERATURES, ADOPTED

As stated on p. 4, mean temperatures cannot well be used for purposes of comparison, as they change somewhat from year to year unless the period of observations is long enough to smooth out accidental irregularities, and certain mean temperatures are adopted

TABLE XV

NORMAL TEMPERATURE

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	25	23	29	40	51	62	71	73	68	60	45	34
2	25	23	30	41	52	62	71	73	68	59	45	34
3	25	23	30	41	52	63	71	73	68	59	44	33
4	25	23	30	42	52	63	71	73	68	59	44	33
5	25	24	30	42	53	63	71	73	68	58	43	32
6	24	24	31	42	53	64	71	72	67	58	43	32
7	24	24	31	43	54	64	72	72	67	58	42	32
8	24	24	32	43	54	64	72	72	67	57	42	32
9	24	24	32	43	54	65	72	72	66	57	42	31
10	24	24	32	44	54	65	72	72	66	56	41	31
11	24	24	32	44	55	65	72	72	66	56	41	31
12	24	25	33	45	55	66	72	72	66	55	40	30
13	24	25	33	45	55	66	72	72	66	55	40	30
14	24	25	34	46	56	66	72	72	65	54	39	30
15	24	25	34	46	56	66	73	72	65	54	39	30
16	24	25	34	46	57	66	73	72	65	54	39	29
17	23	26	35	46	57	67	73	71	64	53	38	29
18	23	26	35	47	57	67	73	71	64	53	38	29
19	23	26	35	47	58	68	73	71	64	52	38	28
20	23	26	36	48	58	68	73	71	64	52	37	28
21	23	27	36	48	58	68	73	71	63	51	37	28
22	23	27	36	48	59	68	73	70	63	50	37	28
23	23	27	37	49	59	68	73	70	62	50	36	27
24	23	28	37	49	59	69	73	70	62	49	36	27
25	23	28	38	49	60	69	73	70	62	49	36	27
26	23	28	38	50	60	69	73	70	62	48	35	26
27	23	28	38	50	60	69	73	70	61	48	35	26
28	23	29	39	50	61	70	73	69	61	47	35	26
29	23	......	39	51	61	70	73	69	61	47	34	26
30	23	......	40	51	61	70	73	69	60	46	34	25
31	23	......	40	......	62	......	73	69	......	46	......	25
Means	23.7	25.4	34.4	45.9	56.5	66.3	72.4	71.2	64.6	53.2	39.2	29.3
Annual normal, 48°.5												

Table XV contains the daily normal temperature. The monthly mean temperatures for the period from 1873 to 1905 were taken as a means of comparison and established as "monthly normals." The daily normals were obtained by plotting down on a large sheet the monthly normals, drawing a curve through the twelve points representing the months, and then scaling off the temperature for each day. The monthly means were then taken from these values and in case of any discrepancy between these monthly means and the original monthly normals the curve was slightly adjusted, so that these two monthly means should be in very close agreement. Ordinarily it requires a period of temperature observations of from 100 to 200 years in order to determine true means that may be accepted as normals without further change.

as normals instead. Table XV gives the adopted daily normal temperatures for Chicago, and a comparison of the data with those in Table XII will show that the values have been so smoothed out as to present a steady rise from the time of lowest readings in winter to the highest readings in summer, and a steady fall thereafter. The normal daily minimum of the year, 23°, extends from January 17

to February 4, while the normal maximum, 73°, covers the period from July 15 to August 5. The normal maximum and minimum do not agree exactly with the actual mean maximum and minimum in Table XII, 74°6 and 21°2, respectively, and there are two reasons for the apparent inconsistency. The periods of observations on which the two tables are based are not of the same length, being 33 years for the normals and 39 years for the mean temperatures; and again, accidental irregularities have given an actual mean minimum slightly too low, and an actual mean maximum slightly too high.

EXAMPLES OF DEPARTURES FROM DAILY NORMAL TEMPERATURES, SELECTED YEARS

The use of the daily normal temperatures in characterizing the various days of a year or month is illustrated in Tables XVI, XVII, and XVIII. The warmest and coldest years, seasons, and months

TABLE XVI

DAILY DEPARTURES FROM NORMAL TEMPERATURE FOR 1911, WARMEST YEAR DURING PERIOD OF OFFICIAL RECORDS, 1871–1911

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	+13	+16	+ 4	−10	−11	+ 6	+15	+ 1	+ 5	− 1	−11	0
2	+ 1	+13	+ 6	− 9	−14	+ 6	+17	− 5	+ **9**	− 3	−15	− 2
3	−17	+ 9	+ 6	− 6	− 4	+11	+18	− 3	0	+ 7	−13	− 5
4	−15	+ 7	+ 2	− 6	− 3	+17	+19	+ 6	+ 2	+ 3	− 6	− 5
5	−11	0	+ 2	− 2	+ 1	+ 6	+**21**	+ 2	+ 7	− 4	+ 2	+ 4
6	0	+ 1	+ 5	− 5	+ 7	+ 6	+ 9	+ 4	− 2	+ 6	+ 7	+ 8
7	+ 6	+ 2	+ 2	−10	+12	+ 1	+ 4	+**11**	+ 1	− 6	+ 2	+12
8	+ 4	+ 2	+ 8	− 7	+14	+ 6	+10	+ 2	− 3	− 5	0	+16
9	− 5	− 2	+16	− 5	+12	+17	+14	+ 8	0	0	+ 4	+21
10	+14	− 9	+ 8	0	+16	+**21**	+10	+ 7	+ 4	+ 5	+**15**	+**22**
11	+18	+ 8	+20	+ 6	+13	+ 7	+ 9	− 4	+ 6	+ 2	+12	+12
12	+12	+13	+12	+ 7	+ 7	− 1	+ 3	− 2	0	+ 4	−18	+ 7
13	+12	+15	+ 3	+**15**	− 3	0	+ 4	− 1	− 4	+ 5	−20	+ 6
14	+ 4	+20	+10	+ 2	+ 6	0	+ 2	+ 9	+ 4	+ 4	− 9	+ 6
15	− 6	+13	− 4	0	+19	+ 5	+ 6	+ 1	+ **9**	+ 2	−11	+ 6
16	− 6	+**21**	−12	0	+22	+ 1	− 3	+10	+ 7	+**12**	− 9	+ 6
17	+ 2	+20	+ 4	+ 2	+23	− 3	− 7	+ 5	+ **9**	+ 6	+ 4	+ 1
18	− 1	+ 9	− 1	+11	+**25**	0	+ 1	+ 1	+ 8	+ 6	−10	+ 1
19	+ 5	+ 4	+ 9	+ 3	+24	+ 4	+ 1	− 3	− 2	+ 2	− 9	+ 4
20	+13	− 1	+16	+ 2	+14	+10	− 3	− 3	− 1	0	− 5	+ 6
21	+ 4	− 7	+**24**	0	+10	+ 8	− 3	+ 3	+ 1	− 3	− 5	+12
22	− 5	+ 1	+12	− 4	+ 5	+16	− 3	− 2	0	− 5	+ 1	+ 8
23	+ 7	+ 7	− 3	− 6	+ 8	+17	− 4	− 6	+ 6	− 6	− 3	+ 5
24	+13	+12	+ 3	− 3	+ 9	+ 7	−11	− 8	+ 2	− 4	− 8	+ 9
25	+18	+14	+12	0	+20	+ 7	−13	− 6	− 2	+ 3	− 1	+ 7
26	+**24**	+ 9	+12	+ 4	+22	+ 9	−10	− 2	− 4	− 6	+ 6	+11
27	+23	+ 2	+ 2	+14	+24	+ 1	− 1	+ 5	+ **9**	−11	+ 9	− 6
28	+11	− 5	−12	+ 6	+ 9	− 8	− 1	0	+ 3	− 4	− 1	−11
29	+17	......	− 3	+ 9	− 1	− 3	+ 1	− 7	0	− 3	−11	+ 4
30	+ 2	......	− 6	− 1	+ 3	+ 9	+ 4	− 6	− 4	− 2	− 6	+ 9
31	+11	......	− 5	......	+ 2	......	+ 5	+ 1	......	− 3	......	− 1
Means	+5.5	+7.0	+4.8	+0.2	+9.4	+6.1	+3.6	+0.6	+2.4	±0.0	−3.8	+5.7
Annual departure, +3°5												

Days of greatest departure in each month entered in bold-faced type.

The year 1878 may strictly be considered the warmest year, instead of 1911, if the proper correction is applied to the latter. (See p. 17.)

have already been discussed in a general way (p. 17), and it will now be interesting to note the temperature in these years from day to day. In order further to appreciate the great variation in daily temperature throughout the year, it was first necessary to have before us the daily normal temperatures discussed in the preceding topic. Tables XVI and XVII show the differences between these normal temperatures and the actual means for each day of the

TABLE XVII

DAILY DEPARTURES FROM NORMAL TEMPERATURE FOR 1875, COLDEST YEAR DURING PERIOD OF OFFICIAL RECORDS, 1871-1911

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	+ 9	+ 1	−13	+ 8	−15	+ 4	− 7	−11	+12	−11	− 3	− 1
2	− 3	+10	−14	+ 1	**−16**	+ 7	− 6	**−12**	+ 8	−11	− 4	+ 6
3	− 3	− 1	−16	+10	− 6	− 1	+ 1	−10	+ 8	− 3	− 3	+ 9
4	−10	**−25**	−12	+ 2	− 4	+ 5	+ 3	− 7	− 2	− 5	− 2	+ 7
5	−22	− 7	− 4	+ 4	− 5	− 5	− 4	− 3	+ 4	− 6	− 5	+14
6	−10	−20	− 5	+18	−10	−10	−10	−10	+ 2	− 8	+ 1	+11
7	− 9	−22	−13	+ 9	0	− 9	− 7	− 4	+ 3	− 8	+ 2	+ 8
8	−14	−24	− 6	+17	+12	− 2	− 6	+ 2	+ 6	−10	+ 4	+ 4
9	**−34**	−11	+ 2	+ 6	+ 2	− 2	+ 1	0	+ 2	−11	+ 2	+ 1
10	−16	− 8	− 2	+ 5	− 2	+ 1	0	− 5	− 7	−12	− 1	+ 7
11	−12	−15	+ 5	0	+ 2	+13	− 7	− 4	− 9	**−18**	+ 8	+ 1
12	+ 1	−27	+ 5	− 5	− 7	− 8	− 2	− 4	− 6	−15	+ 8	0
13	− 8	−15	+11	− 6	− 1	**−17**	− 2	+ 1	− 8	−11	0	+ 2
14	−25	−18	+ 4	− 1	− 6	−13	− 2	0	+ 2	− 4	+ 3	− 4
15	−18	−23	0	− 4	−12	−10	+ 5	+ 1	+ 4	−12	+ 1	+10
16	−12	−17	−15	**−24**	− 6	− 8	− 3	− 2	− 5	−16	− 9	− 9
17	−17	−14	**−19**	**−24**	− 5	− 8	− 6	− 5	−15	− 4	−12	**−23**
18	−12	−14	−18	−13	− 5	−12	**−11**	− 8	−13	−15	0	−17
19	−17	0	−17	0	+ 2	− 8	− 9	− 8	−14	− 6	+ 2	− 6
20	− 5	− 6	−15	−14	+ 6	− 3	− 5	− 3	−16	+ 2	+ 3	+15
21	+13	− 7	−13	−14	+ 9	− 6	− 1	− 9	**−17**	+ 7	−13	+20
22	− 1	+ 5	− 8	− 6	− 1	− 8	+ 1	− 8	−13	+12	−10	+20
23	+ 6	+ 5	− 1	− 3	− 2	+ 8	− 5	−10	−10	+10	− 1	+15
24	+ 3	0	− 3	− 8	0	+ 8	+ 1	− 4	− 5	+ 5	−14	+21
25	−14	− 2	+ 2	−13	0	− 2	+ 3	− 1	− 6	+ 7	− 3	+ 9
26	+ 2	− 9	+ 8	−10	− 2	+ 9	− 3	+ 6	− 6	− 5	+ 1	+ 6
27	+11	−18	+ 6	− 4	+ 1	0	− 7	0	+ 1	− 7	+ 1	+ 2
28	+ 3	−15	− 1	+ 4	+ 9	−13	− 7	+ 8	− 3	+ 7	− 3	+10
29	+ 2	.....	+ 5	− 2	− 3	−10	− 5	+ 3	0	+ 3	**−23**	+15
30	− 1	.....	+18	−10	− 1	− 2	− 6	+ 1	− 8	− 6	− 8	+25
31	−20	.....	+21	.....	+ 7	.....	− 9	+ 9	.....	−10	.....	+29
Means	−7.6	−10.8	−3.4	−2.7	−2.0	−3.3	−3.6	−3.3	−3.7	−5.1	−2.6	+6.7
Annual departure, −3°.4												

Days of greatest departure in each month entered in bold-faced type.

warmest year, 1911, and of the coldest year, 1875, in the official records. Table XVIII shows the departures for a nearly normal year, 1891, and accentuates the contrast. In 1911 there were several days on which the excess in temperature was more than 20°; and in May alone there were 7 such days, the greatest excess being 25° on the 18th, when a maximum of 92° was reached. In 1875 there were a few days on which the excess in temperature was greater than 20°, that on the last day of the year reaching 29°. There was

however, an unusually large number of days with deficient temperature, the greatest departure being −34° on January 9, when a minimum of −20° was reached. In the normal year, 1891 (Table XVIII), there were several well-marked excesses and deficiencies in temperature at various times during the course of the year, but these balanced so nearly that at the end of the period there was a deficiency of only 4°. This departure, if distributed equally among the 365 days of the year, would amount to practically nothing.

TABLE XVIII

DAILY DEPARTURES FROM NORMAL TEMPERATURE FOR 1891, THE YEAR MOST NEARLY NORMAL DURING PERIOD OF OFFICIAL RECORDS, 1871–1911

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	**+20**	+ 7	−11	+ 4	+ 3	+ 6	− 9	− 3	− 2	+ 8	−11	− 2
2	− **5**	+ 8	− 8	− 2	− 2	−10	− 7	− 9	+ 6	**+16**	− 6	+ 6
3	− 3	−17	− 4	−13	− 6	+ 5	− 7	− **7**	**−12**	**+16**	− 6	+17
4	+ 1	**−20**	−14	**−16**	−14	**−17**	− 5	− 7	−10	− 7	− 4	+ 1
5	+ 2	+ 1	− 4	−11	−12	−13	− 7	− 3	− 8	− 8	0	+ 4
6	+ 6	+11	− 3	−10	−12	−11	− 6	+ 4	− 5	− 4	+ 1	− 3
7	+ 3	+12	− 3	− 8	+ 1	− 8	−12	+ 8	− 7	− 6	**+10**	**−18**
8	+ 6	+ 8	0	− 9	+ 8	− 6	**−14**	+10	− 7	− 4	**+10**	− 4
9	+ 7	+ 4	−11	− 7	**+14**	− 1	− 8	**+12**	− 4	− 5	+ 4	+ 6
10	+10	− 4	+ 1	+ 2	− 2	+ 7	− 5	+ 3	− 2	− 2	+ 1	+ 7
11	+ 6	+ 8	+ 6	− 2	− 5	+ 1	+ 2	+ 3	0	− 2	− 1	+ 8
12	+ 4	+13	−12	− 1	+ 3	0	+ 4	− 8	+ 2	− 3	− 2	+ 7
13	− 4	+11	−13	+14	+ 7	+ 2	+ **5**	− 4	− 2	− **1**	−12	+12
14	+ 4	+14	**−20**	0	0	+ 9	− 2	0	+ 3	− 8	− 7	**+20**
15	+ 6	+19	− 4	− 6	+ 7	+10	− 9	− 2	+ 5	**−12**	+ 7	+14
16	+ 5	+17	− 6	+ 4	**−17**	**+12**	− 1	0	+11	− 6	− 5	+ 3
17	+ 3	+ 9	+ **7**	**+16**	− 9	− 9	− 1	+ 6	+15	− 3	**−26**	− 6
18	+ 2	−10	− 1	+15	+ 1	− 7	−11	+ 7	+16	− 4	−20	0
19	+11	0	− 4	− 2	+ 6	− 2	− 9	+ 5	+14	−10	−10	+ 4
20	+14	+10	− 2	+ 4	+ 8	− 6	− 6	+ 5	+14	− 4	− 1	+ 8
21	+11	+ 3	− 2	+12	+ 3	0	− 3	− 3	+ 9	− 3	+ 3	+16
22	+ 9	− 4	+ 3	+14	−15	+ 2	+ **5**	− 8	+13	−10	+ 3	+12
23	+ 5	+15	+ 2	+ 5	−11	+ 5	+ 2	−10	+16	+ 1	0	+13
24	0	**+23**	− 5	− 5	− 7	+ 7	− 9	−12	**+19**	+ 3	−12	+13
25	+ 7	− 5	− 4	+ 5	−10	+10	− 9	− 6	+13	+11	− 9	+16
26	+ 8	−11	− 5	+10	−16	− 3	−11	− 4	+10	+11	− 1	−14
27	+12	−10	− 4	+10	−10	0	− 7	− 8	+17	− 8	− 9	− 2
28	+11	**−20**	− 3	− 4	− 7	+ 4	− 8	**−13**	+11	− 1	−25	+12
29	+17	......	+ 3	+ 7	− 5	+ 2	− 3	− 9	− 6	+11	−23	+10
30	+11	......	+ 6	+13	− 3	− 8	−11	− 9	0	+14	−16	+10
31	+13	......	+ 2	......	+ 7	......	− 7	− 9	......	+ 1	......	+16
Means	+6.5	+3.2	−3.8	+1.1	−3.1	−0.6	−5.4	−2.2	+4.4	−0.6	−5.4	+6.1
Annual departure, 0°.0												

Days of greatest departure given in bold-faced type.

These tables show forcibly how changeable is the temperature from day to day, and how seldom the normal temperature is experienced. The seeming strangeness of this fact disappears when we consider that the normal is simply the mean value of many varying conditions. (For the relation of the various monthly and annual temperatures to their respective normals see Table III.)

EXAMPLES OF DEPARTURES FROM DAILY NORMAL TEMPERATURES, WARMEST AND COLDEST MONTHS

In Plate II are given the curves of daily mean temperatures of the warmest and coldest months from July, 1872, to December, 1910, inclusive. Daily mean temperatures are not available for the period prior to July, 1872. The line of normal temperature is drawn in each case, so that the abnormal features of the various months can be traced easily from day to day. The curves show graphically the wide variations in the mean temperature for the months, especially during the winter season; but while the daily readings in these particular instances were persistently high or low, there was not a single cold month in which the temperature did not rise above normal on at least one day, nor was there a warm month, except January, 1880, in which the temperature did not at some time fall below the normal.

INFLUENCE OF LAKE MICHIGAN ON TEMPERATURE AT CHICAGO

The lake wind is so powerful a factor in determining the temperatures experienced in the city during certain seasons that it requires description in somewhat greater detail than would otherwise be necessary. For a number of years the temperature of the water in the lake was taken by the Weather Bureau. The readings were made at 1 P.M. each day when the surface was not frozen, at the old stone pier which was located at the foot of Monroe Street. The water here was about 8 feet deep, with rocky bottom. During the period of observations, which was ended in 1887, no continuous record of wind direction was made, but for all purposes of comparison, the direction as observed at 2 P.M., one hour after the reading of the water temperature, will serve admirably. Table XIX gives the daily maximum temperature and the daily mean temperature of the air, the temperature of the surface water in the lake, and the wind direction at 2 P.M., as observed in 1884, and a study of the table will bring out the manner in which the lake wind influences the air temperature over the city. The mean temperatures in the table do not show the effect of the lake wind as markedly as do the maximum readings, but the former more closely correspond to the temperature of the water. The temperature of the water near the shore of the lake, when above the point of maximum density of water, 39°, is always higher with an easterly wind of moderate or greater force, as the warm surface water is brought in by it. On the other hand it is lower with

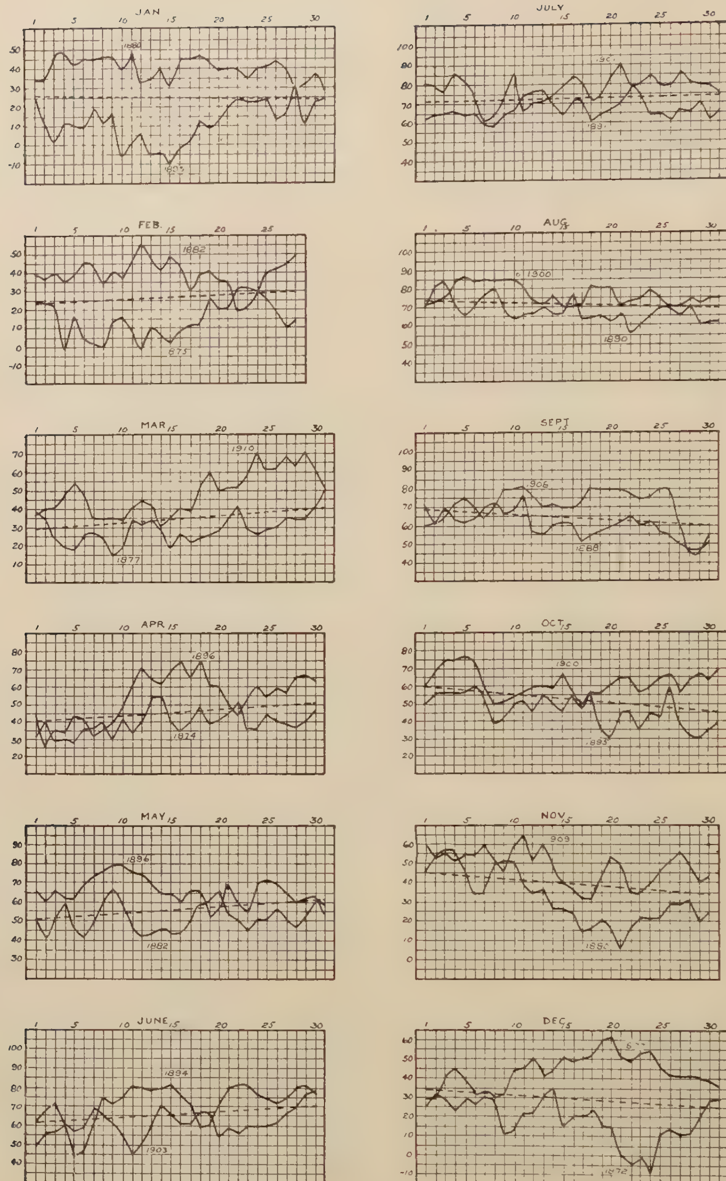


PLATE II.—Contrast between the warmest and coldest months.

Plate II shows the contrast between the warmest and the coldest months during the period of available daily mean temperatures, from July, 1872, to 1910. The heavy lines indicate the average temperature each day of the month, the upper line representing the warmest month and the lower, the coldest. The dotted line in between these two shows the normal daily temperature.

an offshore wind, because the warmer surface water is blown out and the colder strata of lower depths take its place. August 16 and 19 are good examples of these conditions. The maximum air temperature on the 16th was 80°, and on that day the maximum temperature of the water for the season was reached, 73°7, with an easterly wind. On the 19th, just three days later, the maximum air temperature of the month, 91°, occurred with a southwest wind, but the temperature of the water was considerably lower, 68°8. These effects are noticeable only when the wind is of sufficient force to drive the surface water either toward or from the shore, a light wind having no appreciable influence, no matter what its direction, in controlling the temperature of the water.

Air moving over a great expanse of water surface tends to acquire the temperature of that surface. If warmer, the air will lose a portion of its heat to the water by conduction; if colder, it will receive a portion of the water's heat by the same method. The specific heat of air being less than one-quarter that of water, the interchange of heat just mentioned will result in a larger change of air temperature than of water temperature. The temperatures of the overlying air and of the water in Lake Michigan are not often equal, and as a consequence there is a practically constant transmission of heat from

TABLE XIX

Comparison between the Temperature of the Air and the Temperature of the Water, Lake Michigan, 1884

	March				April					March				April			
	Temperature			Wind Direction	Temperature			Wind Direction		Temperature			Wind Direction	Temperature			Wind Direction
	Maximum	Average	Surface of Water		Maximum	Average	Surface of Water			Maximum	Average	Surface of Water		Maximum	Average	Surface of Water	
1....	....	....	......	.....	54	45	40.9	N	18...	....	....	......	.....	49	44	45.1	E
2....	....	....	......	.....	39	**35**	40.5	N	19...			......		49	44	46.0	E
3....	....	....	......	.....	55	44	**38.8**	W	20...	....	....	......	.....	42	38	43.0	N
4....	....	....	......	.....	49	44	40.7	N	21...	....	....	......	.....	41	38	42.4	N
5....	....	....	......	.....	42	38	41.6	NE	22...	....	....	......	.....	43	39	41.1	N
6....	....	....	......	.....	**39**	36	42.1	NE	23...	....	....	......	.....	46	42	41.7	N
7....	....	....	......	.....	45	39	41.4	W	24...	49	44	39.2	E	52	46	43.0	N
8....	....	....	......	.....	40	37	40.9	N	25...	48	43	38.5	E	55	48	48.2	E
9....	....	....	......	.....	40	37	41.1	N	26...	59	49	40.5	NW	67	58	45.0	SE
10....	....	....	......	.....	40	38	40.4	N	27...	59	52	39.9	SE	64	58	45.0	SW
11....	....	....	......	.....	52	44	41.6	SW	28...	54	46	41.8	E	55	48	**48.8**	E
12....	....	....	......	.....	50	45	42.3	E	29...	43	36	......	N	64	52	47.9	E
13....	....	....	......	.....	48	44	42.8	E	30...	35	32	42.7	NE	**77**	**60**	**48.8**	SW
14....	....	....	......	.....	70	57	43.9	S	31...	55	44	41.5	S	...	....	......	.....
15....	....	....	......	.....	60	51	44.3	SW									
16....	....	....	......	.....	48	42	44.1	NW	Means	....	....	......	.....	50.7	44.4	43.3	N
17....	....	....	......	.....	46	40	44.8	E									

TABLE XIX—*Continued*

	May				June			
	Temperature				Temperature			
	Maximum	Average	Surface of Water	Wind Direction	Maximum	Average	Surface of Water	Wind Direction
1....	71	58	50.9	NE	76	68	**54.0**	SW
2....	59	50	**46.8**	E	69	60	59.9	SW
3....	58	52	52.3	E	66	60	58.8	N
4....	65	56	50.0	S	67	60	59.4	E
5....	70	62	50.8	S	72	64	56.2	E
6....	64	56	51.9	NW	69	65	62.4	NE
7....	52	46	50.5	N	72	66	61.8	E
8....	59	51	52.4	NE	78	72	60.1	SW
9....	66	59	52.5	N	72	60	55.2	NW
10....	65	58	51.7	S	**56**	**52**	53.5	NW
11....	56	50	54.3	E	66	56	55.7	N
12....	60	55	**56.9**	E	70	61	62.3	NE
13....	58	54	53.6	NW	59	54	57.8	N
14....	67	55	53.8	SW	60	54	57.8	N
15....	68	56	54.6	NE	63	58	59.6	NE
16....	55	48	54.5	SE	71	64	66.8	E
17....	74	62	54.7	SW	78	72	64.6	SE
18...	70	64	55.6	SE	83	74	60.2	SW
19...	64	60	53.0	NW	74	66	60.8	N
20...	76	62	51.8	SW	72	64	62.4	NE
21...	74	68	56.0	SE	79	73	65.7	E
22...	**78**	**70**	53.1	S	80	74	70.8	NW
23...	73	68	55.0	SW	**86**	**78**	65.6	W
24...	66	58	55.6	SW	84	76	62.1	SW
25...	56	52	56.2	N	70	60	59.6	N
26...	56	51	56.0	N	60	56	59.0	N
27...	55	50	54.9	N	64	60	60.6	N
28...	**47**	**45**	53.7	N	69	62	62.9	N
29...	51	46	53.1	N	77	69	70.7	NE
30...	73	58	53.5	W	70	68	**71.4**	E
31...	75	64	53.0	SW	....	....	......	.....
Means	63.9	56.3	53.3	N	71.1	64.2	61.3	N

	July				August			
	Temperature				Temperature			
	Maximum	Average	Surface of Water	Wind Direction	Maximum	Average	Surface of Water	Wind Direction
1....	77	70	**71.9**	E	75	70	71.7	E
2....	73	69	70.9	E	83	76	71.8	S
3....	75	70	71.6	NE	77	70	66.7	W
4....	68	64	69.1	NE	67	62	**60.6**	NW
5....	75	69	69.1	W	69	61	62.3	E
6....	70	**62**	64.7	NW	70	64	61.7	SW
7....	67	**62**	66.5	NE	67	62	62.3	NE
8....	72	66	65.6	S	**62**	60	61.9	N
9....	70	66	64.8	N	64	**58**	64.9	NE
10....	71	63	66.4	E	68	60	65.7	SE
11....	83	72	65.6	NW	78	68	65.6	W
12....	78	73	66.9	W	77	69	68.3	E
13....	72	66	65.2	NW	77	72	69.4	NE
14....	68	63	65.3	NE	76	72	71.0	NE
15....	68	64	66.9	NE	78	73	72.4	NE
16....	**66**	**62**	67.6	N	80	74	**73.7**	E
17....	72	66	66.6	S	86	77	73.5	S
18...	81	72	67.6	SW	87	79	68.3	S
19...	74	68	67.9	E	**91**	**82**	68.8	SW
20...	75	68	69.6	E	88	80	69.0	S
21...	81	70	68.0	SW	77	72	65.1	NE
22...	**89**	**79**	67.7	W	73	68	67.5	E
23...	83	73	**63.7**	SW	70	66	68.4	NE
24...	83	76	65.0	W	70	62	67.9	SE
25...	76	70	70.0	E	80	71	65.6	W
26...	81	70	68.6	N	70	66	67.0	NE
27...	80	72	70.1	E	70	63	67.7	E
28...	73	70	71.7	N	70	66	66.6	N
29...	75	69	70.3	S	76	72	66.6	W
30...	81	72	71.3	SW	71	64	66.5	NE
31...	72	67	69.8	NE	70	62	66.3	E
Means	75	68.5	67.9	E	74.7	68.5	67.3	NE

TABLE XIX—*Continued*

	September				October					September				October			
	Temperature				Temperature					Temperature				Temperature			
	Maximum	Average	Surface of Water	Wind Direction	Maximum	Average	Surface of Water	Wind Direction		Maximum	Average	Surface of Water	Wind Direction	Maximum	Average	Surface of Water	Wind Direction
1....	77	68	66.8	S	71	65	59.7	N	18...	**62**	**56**	64.7	E	59	52	56.6	E
2....	82	72	66.6	SW	**83**	74	61.0	SW	19...	71	64	62.9	S	71	62	56.7	SW
3....	84	74	67.6	SW	**83**	**76**	61.7	SW	20...	66	62	63.0	N	73	63	56.8	SW
4....	80	75	63.5	NE	77	72	61.2	SW	21...	74	62	62.7	SW	66	57	57.4	SW
5....	86	77	63.9	S	**83**	74	62.7	SW	22...	70	66	64.0	N	52	45	56.4	W
6....	86	79	64.0	S	73	64	61.7	E	23...	69	64	62.8	S	**39**	**34**	53.8	W
7....	79	74	64.8	NE	71	66	60.2	NE	24...	70	66	63.0	W	57	45	52.0	SW
8....	84	75	**68.2**	E	69	58	56.7	NW	25...	66	60	63.7	E	52	42	52.1	E
9....	**89**	**80**	65.4	SW	57	**50**	54.6	W	26...	74	66	63.9	S	55	50	49.8	SE
10....	88	**80**	62.7	SW	64	54	**63.9**	S	27...	75	70	64.4	W	57	48	50.3	W
11....	76	67	**58.9**	N	74	62	54.6	SW	28...	74	70	62.2	SW	51	42	49.3	S
12....	68	64	59.9	NE	67	62	57.7	NE	29...	70	66	63.2	E	55	48	**49.2**	SE
13....	68	65	62.8	NE	62	56	57.1	N	30...	74	70	62.2	W	58	53	49.9	N
14....	68	63	63.2	E	58	54	56.6	E	31...	....	....	......	.....	55	48	49.3	W
15....	85	74	64.5	SW	63	54	55.7	SW									
16....	77	68	66.6	W	69	60	55.9	W	Means	75.5	68.7	63.9	SW	64.2	56.4	56.0	SW
17....	72	64	65.0	W	67	58	56.7	SW									

	November				December					November				December			
	Temperature				Temperature					Temperature				Temperature			
	Maximum	Average	Surface of Water	Wind Direction	Maximum	Average	Surface of Water	Wind Direction		Maximum	Average	Surface of Water	Wind Direction	Maximum	Average	Surface of Water	Wind Direction
1....	58	49	48.6	NW	38	30	33.1	SW	18...	40	36	43.0	NE	....	....	......	.....
2....	51	44	48.4	SE	46	40	34.1	SW	19...	42	36	42.0	S	....	....	......	.....
3....	57	50	**48.8**	E	52	42	35.0	SW	20...	48	42	41.7	SW	....	....	......	.....
4....	50	44	47.4	W	54	46	34.9	S	21...	57	48	41.8	SW	....	....	......	.....
5....	45	40	46.6	NW	**59**	**52**	**36.5**	S	22...	55	50	41.3	S	....	....	......	.....
6....	47	40	46.5	SW	55	50	36.7	SE	23...	55	34	42.3	W	....	....	......	.....
7....	56	47	45.6	SW	44	39	34.7	W	24...	**28**	**16**	38.8	SW	....	....	......	.....
8....	56	50	44.7	E	42	38	34.7	W	25...	40	30	38.3	W	....	....	......	.....
9....	**64**	**54**	45.3	SW	44	34	35.1	E	26...	39	27	35.6	SW	....	....	......	.....
10....	49	46	45.8	N	45	40	33.0	SW	27...	43	34	35.7	NW	....	....	......	.....
11....	53	47	46.1	W	39	33	33.9	NE	28...	30	24	35.8	NW	....	....	......	.....
12....	47	42	45.5	SW	42	36	33.3	NE	29...	33	26	35.0	W	....	....	......	.....
13....	50	45	45.5	N	39	32	34.3	W	30...	38	29	**34.7**	W	....	....	......	.....
14....	58	48	46.3	W	41	36	34.8	SW	31...	....	....	......	.....	....	....	......	.....
15....	60	51	45.7	SW	36	26	34.1	W									
16....	58	52	45.4	SW	**16**	**12**	**32.2**	NW	Means	48.7	40.8	43.1	SW	....	....	......	.....
17....	53	44	44.5	N	....	....	......	.....									

Table XIX contains for a single year 1884, from March 24 to December 16, the period during which the surface was free from ice, the maximum and average daily air temperature in shelter, the temperature of the water at the surface of Lake Michigan at 1 P.M., and the wind direction at 2 P.M. Figures in bold-faced type indicate highest and lowest temperatures.

the one to the other, which results in the air temperature there differing from that over the shores. A lake wind, therefore, tends usually to raise or lower the air temperature in the city. The temperature of the air at Chicago is not influenced by the lake wind in the same degree throughout the year. A comparison of the means of air and water temperatures in Table XIX shows that the

TABLE XIX*a*

MONTHLY AND ANNUAL MEAN TEMPERATURES OF LAKE MICHIGAN AT TWO-MILE CRIB AND MONTHLY AND ANNUAL AIR TEMPERATURES AT WEATHER BUREAU OFFICE, FEDERAL BUILDING, 1902–11

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1902 Water.....	32.0	32.2	32.7	41.5	50.4	61.2	63.6	69.1	62.7	56.0	51.4	35.0	49.0
1902 Air.......	25.2	20.8	38.6	46.4	59.0	64.2	72.4	68.4	60.8	55.2	47.0	26.5	48.7
1903 Water.....	32.0	32.0	36.5	43.8	50.8	55.7	64.2	66.2	65.0	57.4	43.7	32.3	48.3
1903 Air.......	24.0	25.0	40.4	47.2	59.8	61.2	72.2	68.4	64.4	53.6	36.4	20.0	47.7
1904 Water.....	32.0	32.0	32.2	38.2	46.8	56.6	62.7	62.6	61.5	55.7	44.5	33.4	46.5
1904 Air.......	17.7	17.2	35.2	40.7	57.3	64.2	71.0	68.3	64.5	53.4	42.8	26.8	46.6
1905 Water.....	32.0	32.0	34.3	42.1	50.8	59.3	65.6	69.4	62.0	54.6	41.3	33.5	48.1
1905 Air.......	18.1	17.0	39.2	45.5	56.4	65.4	71.2	74.0	67.5	53.4	40.6	31.8	48.3
1906 Water.....	32.1	32.3	32.4	39.9	50.9	55.8	64.3	70.6	64.8	55.1	43.0	34.8	48.0
1906 Air.......	32.6	27.6	30.2	50.7	59.8	68.0	71.6	75.6	70.1	52.8	41.8	32.8	51.1
1907 Water.....	32.3	32.0	34.9	39.5	45.6	53.8	61.7	63.7	61.9	52.4	42.2	34.2	46.2
1907 Air.......	27.8	26.4	42.6	39.8	51.6	66.2	73.3	71.2	64.6	52.6	41.0	32.8	49.2
1908 Water.....	32.0	32.0	34.6	41.3	48.5	57.6	66.4	71.8	65.8	55.0	42.1	33.2	48.4
1908 Air.......	28.6	26.7	40.6	49.0	58.7	68.4	74.3	73.4	70.6	55.2	43.5	31.3	51.7
1909 Water.....	32.4	32.2	33.3	39.8	48.2	56.3	65.4	70.6	64.1	52.6	46.4	34.8	48.0
1909 Air.......	28.8	32.4	36.0	45.0	55.9	66.6	72.3	74.8	64.0	50.6	48.5	21.6	49.7
1910 Water.....	32.0	32.0	35.9	45.0	48.0	57.6	66.7	70.2	64.2	59.2	42.3	32.9	48.8
1910 Air.......	25.6	24.8	48.6	51.2	53.4	68.2	76.0	73.3	65.2	58.6	36.0	26.4	50.6
1911 Water.....	32.2	32.5	34.5	39.7	50.6	62.2	65.4	65.0	66.6	57.2	41.0	34.2	48.4
1911 Air.......	29.2	32.4	39.2	46.1	65.9	72.4	76.0	71.8	67.0	53.2	35.4	35.0	52.0
Means Water...	32.1	32.1	34.1	41.1	49.1	57.6	64.6	67.9	63.8	55.5	43.8	33.8	48.0
Means Air.....	25.8	25.0	39.1	46.2	57.8	66.5	73.0	71.9	65.9	53.9	41.3	28.5	49.6
Departure from mean of water temperature..	−6.3	−7.1	+5.0	+5.1	+8.7	+8.9	+8.4	+4.0	+2.1	−1.6	−2.5	−5.3	+1.6

Monthly averages of lake-water temperatures obtained from tri-daily observations (9 A.M., 2 P.M., and 7 P.M.), taken 24 feet below the lake surface. For this period the temperature of the air averaged 1°.6 higher than that of the water in the lake.

differences grow smaller as the heated season advances, becoming of the opposite kind before the beginning of winter. Table XIX*a* and Fig. 4*a* show the mean temperatures of the water in Lake Michigan and of the air at the Weather Bureau station in Chicago for the period 1902 to 1911, inclusive, by months, and the average differences between the two. The data for the water of the lake was furnished by the City Engineer, from tri-daily observations taken at 9 A.M., 2 P.M., and 7 P.M. at the Two-Mile Crib, 24 feet below the

surface, and indicate more nearly than do the old shore readings in Table XIX the condition of the body of the water toward which the lake wind adjusts its temperature. It will be noticed that the differences are greatest in the spring and early summer, the water being colder than the air by 8°.7 in May, 8°.9 in June, and 8°.4 in July. It

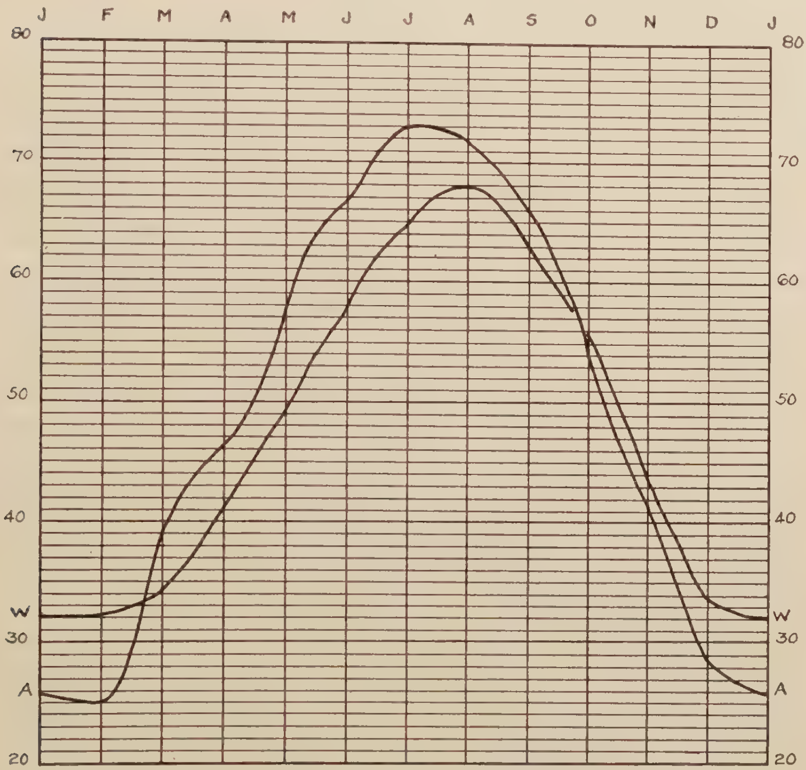


FIG. 4*a*.—Relation of lake and air temperatures.

A=monthly mean temperature of air; W=monthly mean temperature of water in Lake Michigan. Record, 1902–11, inclusive. Water temperatures taken at Two-Mile Crib, 24 ft. below the surface, three times daily: 9:00 A.M.; 2:00 P.M.; 7:00 P.M. About February 20 and September 25, as indicated by the lines crossing each other, the air and water temperatures are the same.

is during the first part of this period, in May and June, that the lake wind influences the air temperatures of the city to the greatest extent. By the end of July the differences have begun to lessen rapidly, and by the first of October the water has become warmer than the air, but is not much in excess until December. Throughout

the autumn the on shore breeze exercises but little effect upon the air temperature, although it moderates severe conditions very much, and tends to hold off frosts until a later time than would otherwise be the case. In December, January, and February, the air temperature over the city averages much below that of the lake water, but the decided moderating influence exerted by lake winds during the early portion of this period is occasionally lost in January and February, when the surface of the lake becomes frozen far enough out to assume the characteristics of a large expanse of land, and has therefore but little effect in raising the temperature of the air above.

It will thus be seen that the lake often serves to break up hot waves in summer, and, when not extensively frozen, cold waves in winter; and because of it hot and cold waves seldom last longer than three or four days at a time. Whenever the wind is from the lake, the tendency is for the air over the city to acquire the temperature of the water in the lake, and the relation is sure to be very close when the wind velocity is high. There was only one pronounced warm wave in the summer of 1884, August 17 to 20, inclusive, and this was broken up in the ensuing days by the lake wind. Table XIX shows that when the wind shifted to the lake on the 21st, the temperature fell rapidly and continued to fall for several days, the maximum temperatures on the 23d and 24th not exceeding 70°, although the temperature of the water changed but little.

While the lake wind is usually felt over the entire city, it is occasionally so light as not to be noticeable over the west and southwest portions, and, as a consequence, local temperature conditions at such times vary considerably. With moderate wind, however, the effect is carried far into the interior, and in the spring its influence is sometimes felt as far inland as Joliet. The chill of the wind from the lake in early spring is rather disagreeable, but in the late spring and summer its coolness is most refreshing. At all times it brings pure air in abundance, and this, together with its moderating effect, is one of the city's valuable assets.

As water acquires and loses heat more slowly than does the air, we should expect that on the average the rise and fall of temperature of the water in Lake Michigan would follow throughout the year the various changes in mean air temperature by a shorter or longer interval, and this is found to be the case except in the coldest weather of winter when the water temperature has reached the freezing point,

below which it cannot fall and remain in the liquid state. Figs. 4*b* and 4*c* show the mean daily temperatures of the air at the Weather

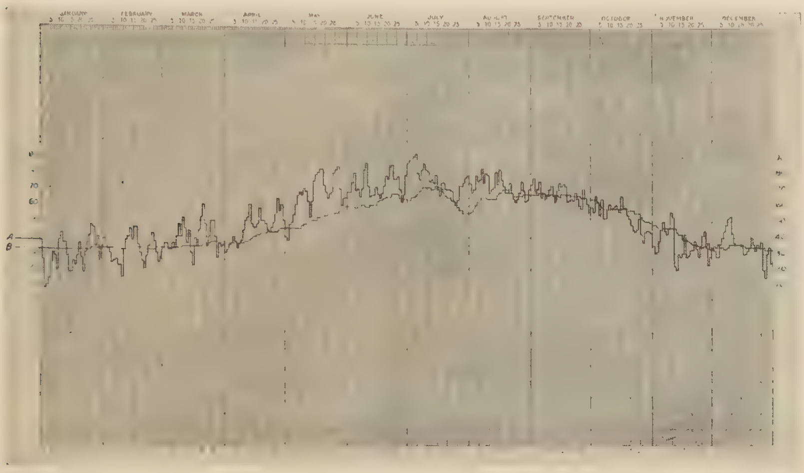


FIG. 4*b*.—Relation of lake temperature and air temperature for 1911, warm year. Lake temperature at Two-Mile Crib; air temperature at Weather Bureau office.

A = mean daily air temperature; B = mean daily water temperature.

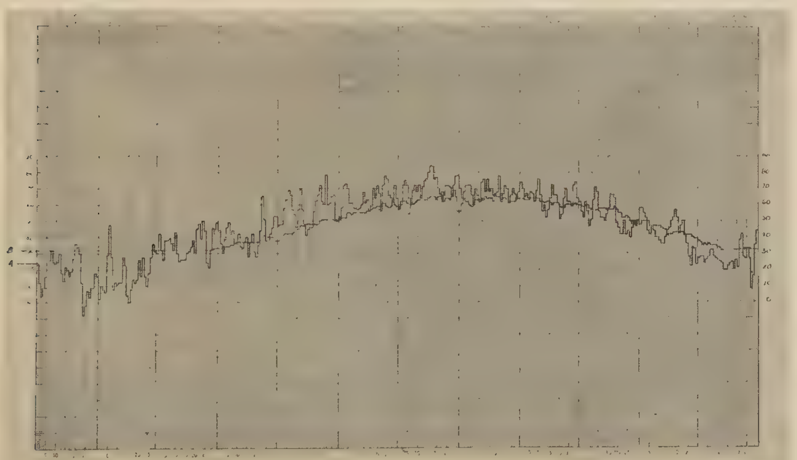


FIG. 4*c*.—Relation of lake temperature and air temperature for 1904, cold year. Lake temperature at Two-Mile Crib; air temperature at Weather Bureau office.

A = mean daily air temperature; B = mean daily water temperature.

Bureau office, and the mean daily water temperatures at the Two-Mile Crib, for 1911, an exceptionally warm year, and for 1904, a cold year, respectively. An inspection of these graphs will bring out the lagging of the change in temperature in the lake behind that of the mean air temperature, the interval ranging from two or three days to nearly a week.

COMPARISONS OF TEMPERATURE AT CHICAGO WITH TEMPERATURES OF OTHER PLACES

1. *Near-by locations: LaGrange.*—In the previous section devoted to the influence of Lake Michigan on the temperature at Chicago, it was noted that the cooling effects of the lake wind in summer are sometimes felt far inland. As a rule, however, the influence of this wind weakens rapidly as the interior is approached, and nearly or quite disappears at 15 or 20 miles. Then again, as the city is left behind, the spread of the open country and the abundant vegetation offer much better conditions for the free radiation of heat, and at night considerably lower minimum temperatures might be expected than would occur in the closely built-up sections of the business district. Table XX, giving the maximum and minimum temperatures for Chicago and LaGrange, and the prevailing wind direction for the former, for the year 1904, will prove interesting after the study of Tables XIX and XIX*a*, as it brings out clearly the remarkable difference a distance of a few miles makes when the city is under the dominance of the lake breeze. The year 1904 was selected for no particular reason except that the record at LaGrange is complete for that entire year, while in most other years it is more or less broken. LaGrange is located on the inner margin of the Valparaiso moraine about 15 miles directly west of the city, and we should therefore expect to find a lower maximum temperature at Chicago throughout the spring and summer whenever lake winds prevail, and in the table this is almost invariably found to be the case. The maximum temperature is usually higher at LaGrange, even when the wind is from some other direction, but there is very little difference during the winter season. March 23, April 24 to 28, May 1 to 3, and June 8 to 19 furnish excellent examples of the pronounced lake-wind effect in spring and summer, for both short and long periods. In the period last named the maximum temperature at LaGrange ranged from 72° to 88°, while during the same time the highest readings at the Chicago Weather office oscillated between 61° and 77°. For this

12-day interval during which northeasterly winds prevailed, the daytime maximum temperatures at Chicago averaged 67°, while at LaGrange the average was 80°, or 13° higher for the inland station. On the other hand minimum temperatures at LaGrange averaged lower throughout the entire year than at Chicago, although there were days here and there when these readings were higher. As previously indicated (p. 9), the minimum temperature should ordinarily be lower in the country than in the city, especially during quiet, clear nights, and numerous instances of this kind can be found in the table. The average difference for the year between Chicago and LaGrange is 3°.9, and ranges somewhat greater during the summer than during the winter, although in exceptional cases differences of 20° or more are to be noted in both seasons, as on January 4, May 25,

TABLE XX

TEMPERATURES AND PREVAILING WIND DIRECTION AT CHICAGO AND LAGRANGE, ILL., FOR A SELECTED YEAR, 1904

	January, 1904					February, 1904				
	Maximum		P.W.D.	Minimum		Maximum		P.W.D.	Minimum	
	Chicago	LaGrange	Chicago	Chicago	LaGrange	Chicago	LaGrange	Chicago	Chicago	LaGrange
1....	27	26	NE	20	14	10	9	S, NW	− 6	− 8
2....	21	24	NE	4	4	15	15	W	6	5
3....	10	12	NW	− 1	− 9	15	18	NW	1	− 1
4....	16	15	SW	2	−18	16	16	SW	− 4	− 5
5....	24	26	SW	7	− 3	43	42	SW	15	10
6....	30	32	SW	22	13	53	52	SW	42	41
7....	36	36	SW	16	18	49	49	NW	7	6
8....	36	37	W	28	24	14	12	NE	2	2
9....	30	34	E	20	11	14	19	NE	10	10
10....	26	28	E	22	21	14	17	NE	8	10
11....	27	30	E	23	23	17	19	N	7	6
12....	34	30	S	25	24	18	21	SE	7	0
13....	27	25	NW	10	10	37	34	S	18	18
14....	20	22	NW	6	− 1	35	33	NW	11	12
15....	31	29	S	12	− 1	11	14	NW	− 2	− 1
16....	29	29	NW	11	13	5	10	NE	− 4	− 7
17....	23	26	NE, NW	8	7	13	13	E	2	− 1
18....	24	22	SE	14	15	15	16	NE	12	13
19....	39	39	SW	15	13	15	22	NE	8	− 4
20....	39	39	NE	32	32	24	32	E	5	− 6
21....	37	35	NE	31	32	31	32	W	20	23
22....	34	33	N	25	25	31	24	W	0	− 2
23....	25	29	W	− 2	2	38	36	NE	19	19
24....	− 2	2	NW, W	−13	−11	21	21	NW	10	10
25....	11	4	NE	−15	−14	16	16	E	5	4
26....	12	9	NW	2	1	23	25	NE	14	11
27....	12	9	S, W	− 6	−12	41	38	S	14	5
28....	14	10	N	4	− 3	39	43	NE	33	33
29....	13	15	S	5	− 2	35	35	E, NE	27	28
30....	26	28	S	9	0	....	....	....	....	....
31....	25	25	NW	6	13	....	....	....	....	....
Means	24.4	24.5	Chicago NW LaGrange NW	11.0	7.8	24.4	25.2	Chicago NE LaGrange N	9.9	8.0

TABLE XX—*Continued*

	March, 1904					April, 1904				
	Maximum		P.W.D.	Minimum		Maximum		P.W.D.	Minimum	
	Chicago	LaGrange	Chicago	Chicago	LaGrange	Chicago	LaGrange	Chicago	Chicago	LaGrange
1....	35	35	SW	25	23	49	53	W	40	40
2....	51	50	S	32	28	41	43	NW	32	32
3....	50	50	NW	13	14	34	39	NE	27	25
4....	34	36	W	19	14	48	42	S	30	28
5....	44	40	S	31	30	53	59	S	38	32
6....	40	38	N	35	33	57	61	W	41	37
7....	46	46	NW	32	32	53	64	E	31	31
8....	40	42	NW	31	28	49	52	S	38	37
9....	36	41	E, SE	28	24	40	42	NW	33	33
10....	52	52	SE, S	34	35	39	42	NW	33	33
11....	34	35	N	27	26	50	54	SW, W	33	31
12....	27	27	NE	23	23	37	45	N	32	31
13....	29	32	NE	23	21	36	41	NE	30	30
14....	27	30	N	24	22	45	44	SW	29	26
15....	30	34	NW	21	21	51	51	N, S	29	28
16....	33	37	SE	26	24	32	43	NE	23	21
17....	32	33	E	30	24	46	51	SW	28	24
18....	40	42	S	28	25	50	63	NE, SW	33	33
19....	44	45	W	33	33	34	44	NE	28	25
20....	33	39	E	26	26	32	40	NE	25	25
21....	59	56	SE	31	31	39	53	NE	31	25
22....	60	58	SW	36	32	52	55	S, SE	37	33
23....	44	55	E	34	28	79	81	S	51	42
24....	65	66	SE	36	33	63	69	NE	39	42
25....	57	43	W	31	29	40	48	NE	36	37
26....	31	29	NW	18	18	40	47	NE	37	37
27....	26	33	NW	16	16	46	58	NE	38	34
28....	41	46	SW	22	21	52	64	NE	41	35
29....	57	49	S	35	29	62	71	N	44	36
30....	45	45	SE	38	39	60	65	N	46	36
31....	57	58	W, SW	41	43	....	....	....	....	....
Means	41.9	42.6	Chicago NW LaGrange NW	28.4	26.6	47.0	52.8	Chicago NE LaGrange N	34.4	32.0

TABLE XX—*Continued*

	May, 1904					June, 1904				
	Maximum		P.W.D.	Minimum		Maximum		P.W.D.	Minimum	
	Chicago	LaGrange	Chicago	Chicago	LaGrange	Chicago	LaGrange	Chicago	Chicago	LaGrange
1....	51	64	NE	43	42	55	68	NE	48	42
2....	55	67	NE	42	40	65	76	E	50	46
3....	54	71	NE	42	43	87	90	SE	58	45
4....	66	80	SE	50	42	82	83	S	64	63
5....	69	81	SE	57	49	77	....	SW	64	....
6....	79	82	S	59	54	65	79	W	57	54
7....	77	78	SW	56	59	67	69	NW	55	50
8....	71	73	SE	43	47	62	72	NE	54	52
9....	62	66	NW	45	46	63	76	NE	52	50
10....	52	58	SE	40	40	61	75	NE	53	51
11....	69	72	S	45	40	62	77	NE	53	50
12....	80	71	SW	60	58	67	82	NE	53	48
13....	67	66	W	47	46	76	88	SE	59	52
14....	52	55	NW	44	42	68	82	N, NE, SE	54	56
15....	44	52	NE	38	36	73	82	NE	53	53
16....	51	56	NE	39	32	60	73	NE	53	50
17....	50	51	NE	42	36	65	82	NE	53	41
18....	50	63	N	42	38	77	86	SE	62	41
19....	66	66	NW	47	45	70	82	NE	58	58
20....	68	77	NE	55	50	83	88	SW	60	57
21....	74	86	SE, W	57	52	76	79	NW	58	61
22....	83	85	SW	61	58	60	75	NE	52	50
23....	70	75	NE	55	56	86	75	S	59	50
24....	72	75	SE	49	46	88	91	SW	67	71
25....	87	89	SW	70	41	82	83	SW	70	67
26....	74	75	SW	45	49	71	77	NE	62	60
27....	71	74	NW	51	46	67	76	NE	60	54
28....	75	77	S	55	48	67	75	SE	61	54
29....	74	75	S	58	56	81	84	W	62	54
30....	58	60	NE	42	39	71	77	W	58	55
31....	56	68	NE	45	40	....	....	....	....	....
Means	65.4	70.6	Chicago NE LaGrange W	49.2	45.7	71.1	79.4	Chicago NE LaGrange SE	57.4	52.9

TABLE XX—*Continued*

	JULY, 1904					AUGUST, 1904				
	Maximum		P.W.D.	Minimum		Maximum		P.W.D.	Minimum	
	Chicago	LaGrange	Chicago	Chicago	LaGrange	Chicago	LaGrange	Chicago	Chicago	LaGrange
1....	61	66	NE	53	49	78	84	NW	62	58
2....	68	76	SE	56	44	66	76	NE	62	55
3....	83	89	S	60	49	74	82	SE	61	51
4....	80	89	SW	70	69	82	85	SW	63	60
5....	76	89	SE	67	56	81	84	W	62	57
6....	70	88	NE	57	57	78	84	NW	65	58
7....	62	71	NE	58	57	74	80	W	59	54
8....	78	80	SW	60	56	64	76	NE	55	46
9....	79	85	W	66	68	82	88	S	59	46
10....	71	85	E	64	58	70	77	NE	61	60
11....	80	88	SE	65	59	66	78	NE	58	48
12....	68	80	N, NE	60	61	85	89	SE, SW	62	50
13....	80	84	W	62	55	85	81	SW	66	66
14....	85	89	S	65	60	72	86	N, NE	64	58
15....	86	91	W	66	63	86	89	SW	65	60
16....	90	98	SW	71	62	75	87	N	62	61
17....	94	97	SW	75	73	76	89	NE	64	64
18....	92	99	SW	75	72	67	81	E	64	61
19....	80	93	NE	71	68	72	75	SE	62	61
20....	84	93	NW	70	63	77	80	N	60	60
21....	74	85	NE	67	62	90	91	SW	66	62
22....	72	85	NE	62	57	67	77	NE	59	59
23....	66	77	NE	59	53	76	80	SW	58	48
24....	69	81	NE	64	53	83	87	SW	60	50
25....	82	88	SW	61	51	78	80	NW	61	66
26....	79	84	SW	65	60	66	77	SE	56	48
27....	80	88	SW	62	63	73	81	SW	58	48
28....	69	82	NE	62	58	81	84	SW	60	50
29....	80	86	SE	65	56	73	75	NE	61	61
30....	88	90	SW	67	66	66	77	NE	60	57
31....	87	90	W	68	68	71	81	SE	64	61
Means	77.8	86.0	Chicago SW LaGrange W	64.3	59.5	75.3	82.2	Chicago NE LaGrange NE	61.3	56.1

TABLE XX—*Continued*

	September, 1904					October, 1904				
	Maximum		P.W.D.	Minimum		Maximum		P.W.D.	Minimum	
	Chicago	LaGrange	Chicago	Chicago	LaGrange	Chicago	LaGrange	Chicago	Chicago	LaGrange
1....	82	89	SW	67	66	72	74	W	52	48
2....	77	81	W	64	65	60	59	NE	52	44
3....	71	74	W	59	56	59	64	S	45	38
4....	76	78	W	58	51	73	73	S, SW	50	44
5....	68	78	NE	59	55	64	63	NE	49	47
6....	74	82	SE	63	54	49	52	NE, E	45	37
7....	72	75	NW	62	54	60	60	S	42	31
8....	65	73	NE	60	58	72	74	SW	54	51
9....	80	80	SW	58	51	77	80	SW	65	60
10....	87	88	SW	64	51	78	81	SW	59	60
11....	73	73	NE	60	56	59	61	NE	53	52
12....	60	64	E	52	44	53	57	NE	50	47
13....	65	65	SE	54	42	53	58	E	50	43
14....	58	60	NW	47	44	53	56	E	47	37
15....	67	69	SW	47	39	58	66	SE	50	37
16....	76	78	SW	52	51	69	72	S	48	37
17....	85	87	SW	59	48	78	77	SW	56	46
18....	73	73	NE	60	61	75	76	SW	57	48
19....	72	78	SE	60	60	74	73	S	54	44
20....	70	66	NE	52	44	54	63	SW	44	43
21....	55	57	NE	47	44	50	51	W	43	40
22....	60	64	SE	47	42	45	49	NW	39	35
23....	76	78	S	51	43	50	54	W	35	32
24....	72	73	SW	67	67	55	57	W	44	42
25....	67	77	NE	58	59	48	52	W	37	33
26....	66	69	NE	58	51	50	55	NE	37	33
27....	63	72	NE	55	52	46	49	SW	34	30
28....	83	83	S	62	59	57	59	SW	34	31
29....	79	81	W	69	64	59	67	NE	42	34
30....	69	69	NW	58	55	50	57	SE	44	35
31....	....	....	....	....	....	62	65	SW	39	28
Means	71.4	74.5	Chicago SW LaGrange SW	57.6	52.9	60.1	63.0	Chicago SW LaGrange SW	46.8	40.9

TABLE XX—*Continued*

	November, 1904					December, 1904				
	Maximum		P.W.D.	Minimum		Maximum		P.W.D.	Minimum	
	Chicago	LaGrange	Chicago	Chicago	LaGrange	Chicago	LaGrange	Chicago	Chicago	LaGrange
1....	67	70	SW	48	38	31	30	NE	23	17
2....	67	69	SW	49	38	31	31	NE	25	21
3....	60	69	NE	50	39	29	30	NE	26	25
4....	58	69	NE	45	39	26	26	W	21	14
5....	47	49	NE	42	37	32	32	W	20	16
6....	45	48	N	38	30	36	36	SW	20	13
7....	55	57	NE	37	32	36	36	W	27	22
8....	47	45	NE	40	36	35	36	NE	30	26
9....	44	47	NE	36	36	31	33	E	24	25
10....	42	43	NE	38	36	30	32	NW	24	22
11....	45	46	NW	32	27	28	28	S	24	20
12....	45	46	W	27	24	29	26	NW	21	20
13....	40	41	N	31	27	29	21	SW	19	5
14....	45	47	NW	34	36	24	25	NE	16	7
15....	54	55	SW	33	28	23	25	SW	16	2
16....	53	62	SE	40	24	29	29	SE	15	− 2
17....	58	59	SW	42	37	32	31	NE	17	15
18....	65	66	SW	40	30	34	34	SW	16	11
19....	66	68	SW	48	40	26	29	NW	15	15
20....	60	60	N	43	38	32	30	NW	19	17
21....	49	51	SW	35	28	28	28	SW	14	5
22....	55	57	W	39	34	51	49	SW	26	24
23....	58	59	NW	43	35	54	53	SW	31	32
24....	43	47	NE	39	35	31	32	E	25	25
25....	42	43	NW	30	27	29	30	E	25	29
26....	32	32	NW	23	20	37	35	SE	29	28
27....	26	30	NW	19	17	43	42	SW	11	11
28....	44	41	S	25	24	11	11	W	4	6
29....	44	44	W	22	19	30	29	SW	2	2
30....	27	30	W	19	16	42	42	SW	28	28
31....	....	....	....	....	....	49	49	SW	38	29
Means	49.4	51.7	Chicago SW LaGrange SW	36.2	30.9	32.5	32.3	Chicago SW LaGrange SW	21.0	17.1

Table XX contains the daily maximum and minimum temperatures at Chicago and LaGrange, Ill., and the prevailing wind direction at Chicago for a selected year, 1904. Thermometers at Chicago were exposed in a shelter on the Auditorium Tower, and those at LaGrange were in a shelter a few feet above the sod.

Summary of Table XX

Stations		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Prev. Wd. Dir., Chicago..		NW	NE	NW	NE	NE	NE	SW	NE	SW	SW	SW	SW	SW
Mean Max. Temp......	Chicago..	24.4	24.4	41.9	47.0	65.4	71.1	77.8	75.3	71.4	60.1	49.4	32.5	53.4
	LaGrange	24.5	25.2	42.6	52.8	70.6	79.4	86.0	82.2	74.5	63.0	51.7	32.3	57.1
Mean Min. Temp......	Chicago..	11.0	9.9	28.4	34.4	49.2	57.4	64.3	61.3	57.6	46.8	36.2	21.0	39.8
	LaGrange	7.8	8.0	26.6	32.0	45.7	52.9	59.5	56.1	52.9	40.9	30.9	17.1	35.9
Mean Monthly Temp......	Chicago..	17.7	17.2	35.2	40.7	57.3	64.2	71.0	68.3	64.5	53.4	42.8	26.8	46.6
	LaGrange	16.2	16.6	34.6	42.4	58.2	66.2	72.8	69.2	63.7	52.0	41.3	24.7	46.5
Mean Daily Range.....	Chicago..	13.4	14.5	13.5	12.6	16.2	13.7	13.5	14.0	13.8	13.3	13.2	11.5	13.6
	LaGrange	16.7	17.2	16.0	20.8	24.9	26.5	26.5	26.1	21.6	22.1	20.8	15.2	21.2

and June 18, 1904. During the summer of 1904 there were but 4 days on which the temperature reached a maximum of 90° or over at Chicago, while there were 11 such days at LaGrange. On some of these warm days, when with a prevailing offshore wind the temperature was higher at LaGrange than in the city, the wind temporarily shifted to the lake for a few hours during the afternoon, thus lowering the maximum temperature sufficiently to affect the mean for the day as well. The temperature data for LaGrange for the warm summer of 1913 are not available, but a comparison between the readings at Joliet, about 18 miles farther inland, and Chicago shows that during the months of July and August there were at the former place a total of 24 days in which the maximum reached 90°, while in Chicago the total equaled only 11. This example is given here, as the heat of the summer of 1913 was pronounced over a large area, and the data emphasize the moderating influence of the lake as brought out in the table. The greater frequency of severe temperatures in the winter at LaGrange is also apparent from Table XX, where it will be seen that there were 22 days at this inland station with a minimum of zero or below in 1904, while there were but 10 days of similar character at Chicago. As a consequence of the ordinarily higher maximum and lower minimum at LaGrange, its daily range of temperature is correspondingly greater, averaging for the year, 21°.2, as compared with 13°.6 in the city. The average maximum temperature for 1904, 57°.1, was 3°.7 higher than that at Chicago, while the average minimum, 35°.9, was 3°.9 lower. In the summer months the mean daily range at LaGrange was 26° or more, and averaged about 10° greater than in the colder season, while at Chicago the range in comparison was fairly even throughout the year. Yet, in spite of the great difference between the maximum and minimum temperatures of the two places, it is interesting to note that the mean temperatures for the year as a whole differed only by 0°.1, Chicago averaging 46°.6 and LaGrange 46°.5. From this it will readily be seen that mean annual temperatures alone are far from conclusive in the comparison of climates, but that the range of temperature, the upper and lower limits, and the frequency of extreme conditions must be taken into consideration.

2. *Northern Illinois.*—Table XXI gives the mean annual temperatures for 23 stations over northern Illinois, including Chicago, for the entire period of their records up to and including 1906. The length of these records necessarily varies considerably for the different

stations, most of the observers rendering voluntary services, which have been more or less interrupted. Unfortunately, the mean maximum and mean minimum temperatures for these places are not available, but the greater daily range holds good for these inland stations just as was shown to be the case at LaGrange in the previous paragraph. This statement is borne out by the highest and lowest readings observed during the period of record, the minimums ranging from 1° to 9° lower than the absolute record of −23° at Chicago,

TABLE XXI

MEAN TEMPERATURES AT STATIONS IN NORTHERN ILLINOIS

Station	Length of Record, Years	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Aledo........	8	24.1	21.6	39.5	49.7	61.2	68.6	74.1	71.8	65.6	53.5	37.4	27.3	49.5
Antioch......	7	20.7	19.1	36.5	44.4	57.0	65.4	72.1	69.2	63.8	49.6	37.6	25.7	46.8
Ashton.......	14	22.1	19.9	34.7	47.8	59.8	67.9	72.8	70.9	64.1	51.5	37.1	24.4	47.8
Aurora.......	29	20.8	22.4	34.6	48.0	59.2	68.9	73.2	71.0	63.8	51.5	37.2	26.4	48.1
Cambridge...	16	22.3	22.1	36.3	50.4	62.4	70.0	75.2	73.1	65.7	53.5	38.4	26.4	49.6
Chicago......	36	24.0	25.5	34.9	46.2	56.6	66.5	72.3	71.2	64.8	53.2	39.2	29.3	48.7
Davenport, Ia.	35	21.4	24.0	35.5	50.2	61.1	70.2	75.1	72.8	65.4	53.4	38.5	27.6	49.6
Dixon.......	18	20.5	20.6	34.8	48.7	59.8	69.5	74.0	72.0	64.7	51.7	36.6	25.4	48.2
Dubuque, Ia..	35	18.6	21.5	33.6	49.1	60.4	69.2	74.2	71.8	63.9	51.9	36.1	25.1	48.0
Galva.......	16	22.3	21.0	36.6	49.8	61.2	69.8	74.4	72.5	65.6	53.1	37.6	25.9	49.2
Henry.......	20	23.1	23.7	36.9	50.0	61.4	70.4	74.4	72.3	65.5	52.6	38.4	28.6	49.8
Joliet........	17	24.4	22.6	37.0	48.7	61.0	69.5	73.9	71.7	64.8	52.1	38.8	27.7	49.4
Kishwaukee..	20	20.3	20.8	33.8	47.7	58.3	68.5	73.1	70.8	63.6	51.3	36.9	26.2	47.6
LaGrange	16	23.0	21.8	35.5	47.5	58.5	68.2	73.1	71.1	64.2	52.1	38.0	26.8	48.3
Lanark......	19	20.8	20.6	33.3	47.7	58.9	67.9	72.6	70.2	62.7	50.3	35.9	25.3	47.2
LaSalle.......	33	22.3	25.0	36.8	49.8	60.8	70.1	75.3	72.0	63.9	51.9	37.8	27.5	49.4
Morrison.....	14	21.2	20.0	35.0	49.3	60.4	68.6	73.3	71.7	64.7	53.1	37.9	25.0	48.4
Ottawa......	22	24.0	24.4	37.0	50.6	61.4	70.9	75.2	72.2	65.4	53.2	39.0	29.2	50.2
Streator......	15	25.1	22.7	38.5	49.8	61.5	70.5	75.0	72.9	66.6	53.9	39.7	27.9	50.3
Sycamore.....	28	19.6	20.9	33.1	47.1	58.2	67.8	71.9	69.6	62.6	50.3	35.9	25.6	46.9
Tiskilwa......	14	23.6	21.1	36.0	49.1	61.5	69.6	74.0	72.1	65.1	52.6	38.4	26.3	49.1
Walnut......	17	23.0	22.2	37.5	51.2	62.3	71.0	75.5	73.5	66.9	54.7	38.7	27.2	50.3
Winnebago...	21	20.7	20.0	33.7	47.8	58.3	68.3	72.8	70.7	63.4	51.2	36.0	25.5	47.4
Means.......	......	22.1	21.9	35.7	48.7	60.0	69.0	73.8	71.6	64.6	52.3	37.7	26.6	48.7

Table XXI gives the mean monthly temperatures of the various stations in northern Illinois, together with the annual values. The data are based upon different periods of observation, as the stations were not all established at the same time, but the record in each case extends to and includes the year 1906.

and the maximums exceeding the city's record of 103° by the same amounts (*Bulletin W*, *Summary of Climatological Data for the United States*, sec. 64, p. 6, U.S. Weather Bureau). It is a remarkable fact that the average of the annual means for all these various stations is 48°.7, exactly the same as the 36-year mean for Chicago, and this is even more significant as to the indefiniteness of annual values for purposes of comparison than was the small difference between the means for the year 1904 at LaGrange and Chicago. In individual cases, too, the maximum and minimum temperatures at many

of these places show greater departures from the readings observed at Chicago than does LaGrange, yet the annual means do not differ appreciably.

3. *Other portions of the United States.*—To extend in a very general way the comparison of the mean temperature of Chicago with that in other portions of the United States, Plate III has been introduced at this point, giving the annual isothermal lines for the entire country. It will be noted that the isotherm representing the mean annual temperature of 50° passes east-westerly through northern Illinois a short distance south of Chicago, and this is in harmony with the conditions prevailing in that section of the state as brought out in the discussion of Table XXI (p. 53). This plate shows the southward dip of the lines in the mountain regions, indicating the influence of the greater elevations in lowering the temperatures of those districts; and the northward dip in the great valley of California, where bright and almost uninterrupted sunshine during the daytime results in a region of unusual warmth. As, however, the map gives no information whatever as to daily ranges, or seasonal ranges, of temperature, comparisons between the climatic conditions of different places must be made with caution if it is used alone. Space prevents the publication of isothermal charts of the various seasons, but in those of spring the influence of the cold water of the Great Lakes is distinctly to be seen in the southward bending of the lines in that region, while in the summer the opposite trend is given to the lines passing over the superheated areas of the plains states stretching eastward from the foothills of the Rockies.

Table XXII and Fig. 5 give more detailed data regarding the temperature conditions of various sections of the country, as represented by 15 cities selected in the different regions. The monthly and annual normal temperatures are shown for these places, including Chicago, and will serve to particularize more clearly the information to be gained from a study of Plate III, but even monthly normals or means present the same disadvantages in comparisons as do annual values, only in lesser degree. The mean temperatures of two places may be exactly the same and yet, as previously pointed out, their variation in temperature may differ radically. For instance, the mean temperature of Chicago is only 4° lower than that of Portland, Ore., and to the casual observer this might be taken to indicate that higher temperatures prevail at the latter place. This is, indeed, pronouncedly the case in winter, but in the summer season the

NORMAL TEMPERATURE, ANNUAL, 1871-1908

PLATE III.

relation is reversed. At Portland the range in temperature from month to month and from day to day is very small, especially during the colder weather of the rainy season, from November to May. A city whose average annual maximum temperature is 70° and whose average minimum temperature is 30° will have an annual mean of 50°; another city may have the same annual value, but its average maximum and minimum may be 60° and 40°, respectively. We must therefore study the ranges in temperature as well as the average monthly and annual means in order to make proper comparisons.

TABLE XXII

MONTHLY AND ANNUAL NORMAL TEMPERATURES, SELECTED CITIES IN THE UNITED STATES

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Portland, Ore	39	41	46	51	57	61	66	66	61	53	46	41	52
San Francisco, Cal	50	51	53	54	56	57	57	58	59	58	56	51	55
Yuma, Ariz	55	59	64	70	77	85	91	90	84	72	62	56	72
Havre, Mont	14	15	27	43	54	62	68	67	58	44	31	21	42
Denver, Colo	29	31	39	48	57	66	72	70	63	51	39	32	50
El Paso, Tex	44	49	56	64	72	80	80	79	73	62	51	45	63
Moorhead, Minn	3	7	21	41	55	64	69	66	57	43	24	11	38
Omaha, Neb	20	24	36	50	62	72	76	74	66	54	38	27	50
Galveston, Tex	53	56	62	69	75	81	83	83	79	72	63	56	69
Marquette, Mich	16	16	24	38	49	58	65	64	57	46	32	23	40
Chicago, Ill	24	25	34	46	56	66	72	71	65	53	39	29	48
New Orleans, La	53	56	62	68	74	80	81	81	78	69	61	54	68
Northfield, Vt	15	17	26	40	54	63	67	63	55	44	32	20	41
New York, N.Y	30	31	38	48	59	68	74	72	66	56	44	34	52
Jacksonville, Fla	54	57	62	68	74	79	81	80	77	70	61	55	68

Table XXII contains the monthly and annual normal temperatures for 15 selected cities in the United States. The values are shown graphically in Fig. 5, the cities being arranged from west to east over the northern, central, and southern portions of the country.

Plates IV and V show the extremes in temperature which have been experienced in the various portions of the country, and emphasize features which cannot be brought out in the plate, figure, and table immediately preceding. The highest temperatures, as shown on Plate IV, occur in the desert and semiarid regions of Arizona and California, while the lowest temperatures, as shown on Plate V, are to be found in northeastern Montana. Moreover, in the plains states as far north as the Dakotas summer maximum temperatures are higher than is the case in the extreme South. There is practically no portion of the country in which the temperature has not at some time or other fallen as low as 30°, and zero temperatures have occurred as far south as the east-central Gulf coast.

In endeavoring to comprehend the temperature conditions of Chicago in relation to those of other portions of the United States, it will now be helpful to secure a view, bird's-eye, as it were, of actual

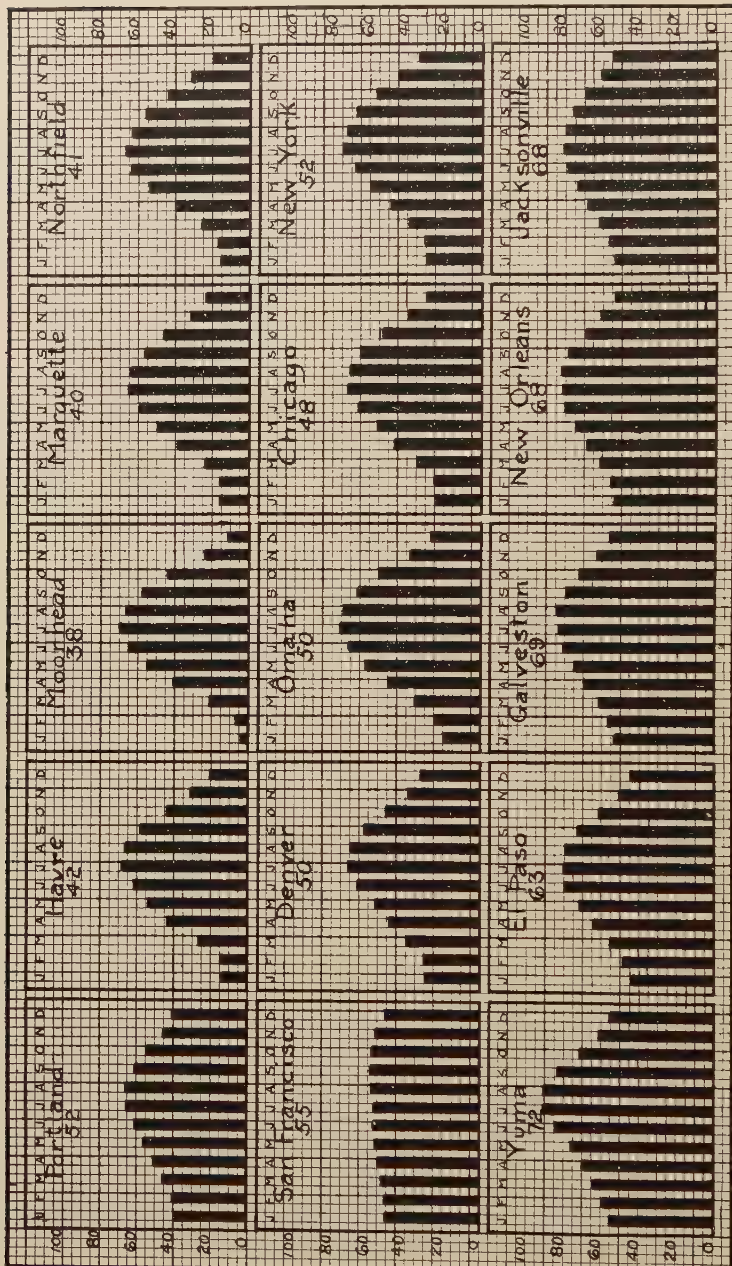


FIG. 5.—Monthly and annual normal temperatures for 15 selected cities (see Table XXII). Mean annual temperature given in figures under the name of the city.

HIGHEST TEMPERATURES OBSERVED AT WEATHER BUREAU STATIONS, 1871-1908

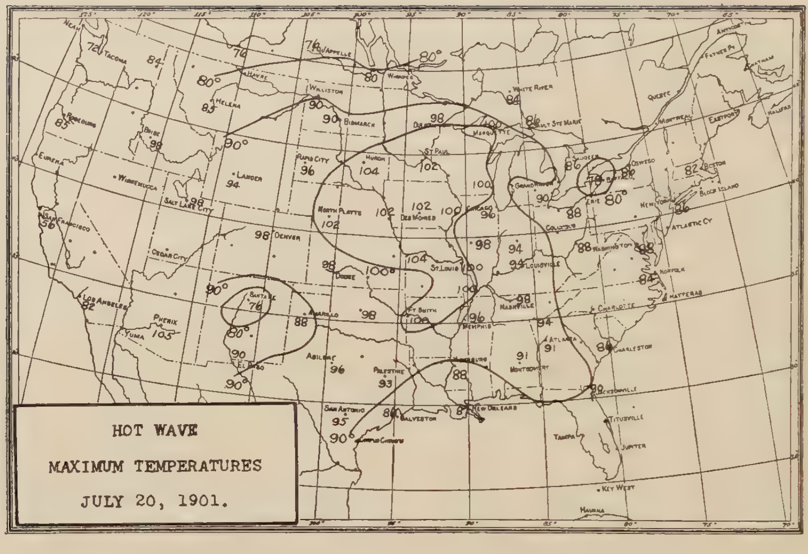
PLATE IV.

LOWEST TEMPERATURES OBSERVED AT WEATHER BUREAU STATIONS, 1871-1908

PLATE V.

periods of extreme heat and cold. During July, 1901 (Plate VI), one of the most severe hot waves on record prevailed over the greater portion of the country, a maximum temperature of 103° being reached at Chicago on the 21st, and readings of from 104° to 106° being general in the middle Mississippi and lower Missouri valleys, as indicated on the second map of the plate. The maps of July 22 and 23 show the hot wave continuing over the interior portions of the country with even greater intensity than on the two preceding days, but broken over much of the Great Lakes region. The break in temperature was especially pronounced at Chicago, where the temperature on the last two days did not rise above 76° and 82°, respectively. The low temperature at Chicago was ushered in and maintained by the lake breeze, which blew steadily throughout the daytime hours, and in this case proved itself indeed the "life-saver of the community." The pressure conditions which produced this great heat period, and the adjustment which permitted the lake wind, are discussed later (p. 353). A severe cold wave swept over the northern and central states during the early part of February, 1906, the morning temperatures of which on the 5th and 6th are shown in Plate VII. The cold was very intense throughout the northern tier of states, as indicated by the lines and figures in the plate. On the morning of the 5th the readings were as low as −48° in the northern Lake Superior region, and had reached −2° in southwestern Missouri, and low temperatures continued generally during the 6th with but slight moderation, yet on the two days in question 12° and 10° above zero were the morning readings in Chicago, the wind shifting to the lake and tempering decidedly the cold in the city. Such conditions, as indicated on p. 44, happen frequently during the winter season.

In addition to mean temperature and the extent of temperature range, the frequency of hot and cold periods is important in establishing the temperature features of any locality. Fig. 6 and Tables XXIII and XXIV give the average monthly and annual number of days with maximum temperature of 90° or over, and minimum temperature of zero or below, for certain stations selected so as to cover practically the entire country. Chicago averages 8 days in each summer with maximum temperature of 90° or over, as does St. Paul, Minn., while Bismarck, N.D., farther to the northwest, averages 14.2 such days. On the other hand, while Chicago averages in winter 9.2 days with temperatures of zero or below, St. Paul experiences nearly 4 times as many, 34.5, and Bismarck nearly 6



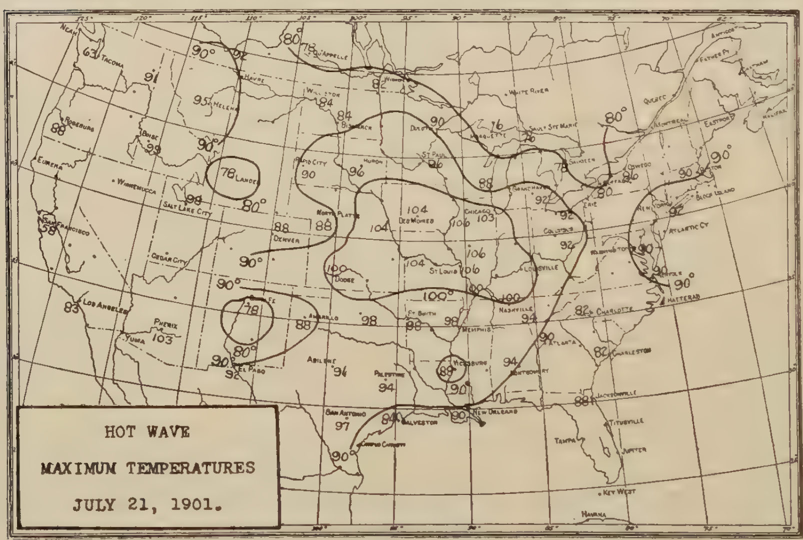
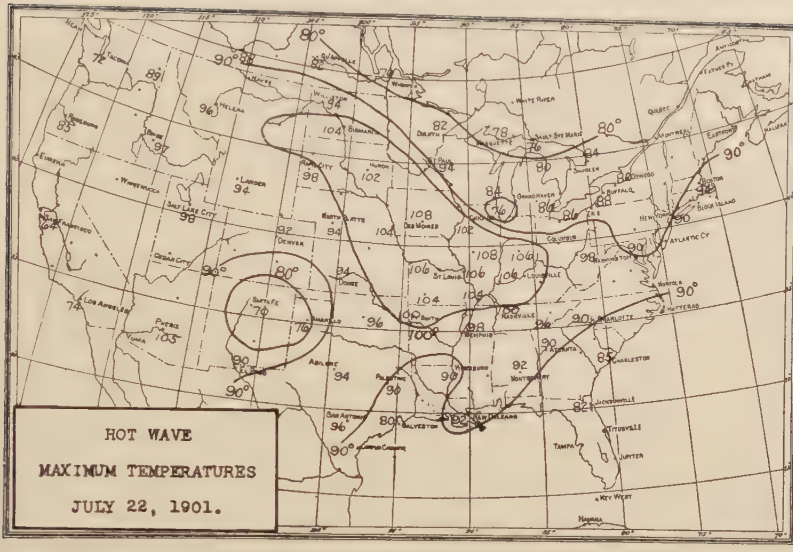


PLATE VI.—Continuous lines, or *isotherms*, connect places of equal temperatures.



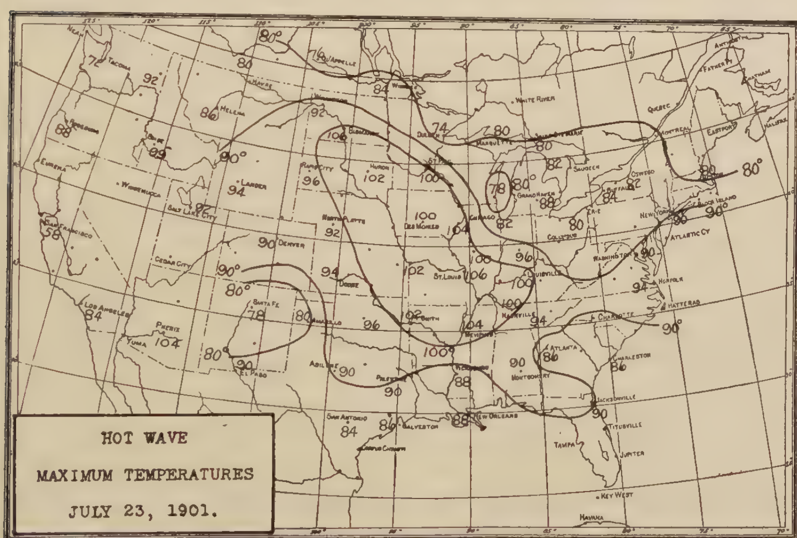
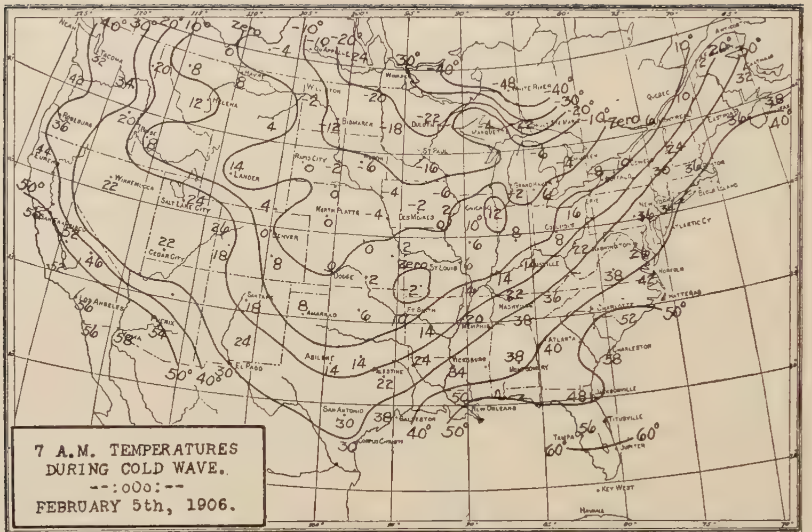


Plate VI (*continued*).—Continuous lines, or *isotherms*, connect places of equal temperatures.



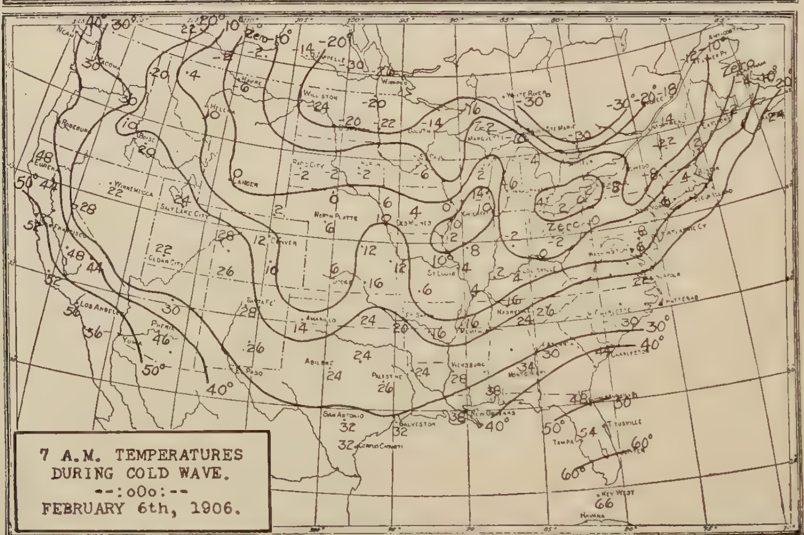


PLATE VII.—Continuous lines, or *isotherms*, connect places of equal temperature.

times as many, 54.3. With the interior cities of the West and South, Denver and St. Louis average more than three times as many hot days as does Chicago, and Denver has the greater number of days with zero temperature also. New York City averages 6.8 days with maximums of 90° or over, somewhat less than Chicago, while Buffalo, N.Y., and San Francisco, Cal., have low averages

TABLE XXIII

AVERAGE NUMBER OF DAYS EACH MONTH WITH MAXIMUM TEMPERATURE 90° OR ABOVE

(These values are shown graphically in Fig. 6)

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Bismarck, N.D.	0	0	0	0.1	0.4	1.7	5.4	5.1	1.6	0	0	0	14.2
St. Paul, Minn.	0	0	0	0	0.1	1.5	3.4	2.2	1.1	0	0	0	8.0
Chicago, Ill.	0	0	0	0	0.1	1.2	3.8	2.1	0.8	0	0	0	8.0
Buffalo, N.Y.	0	0	0	0	0	0	0.3	0.1	0	0	0	0	0.4
New York, N.Y.	0	0	0	0	0.2	1.5	3.1	1.3	0.6	0	0	0	6.8
San Francisco, Cal.	0	0	0	0	0.1	0.3	0.1	0.1	0.4	0.1	0	0	1.1
Denver, Colo.	0	0	0	0	0.2	4.7	10.9	8.0	1.4	0	0	0	25.2
St. Louis, Mo.	0	0	0	0	0.5	5.4	10.4	8.5	3.5	0.2	0	0	28.5
New Orleans, La.	0	0	0	0	0.8	9.0	14.8	13.6	5.0	0.2	0	0	43.3

TABLE XXIV

AVERAGE NUMBER OF DAYS EACH MONTH WITH MINIMUM TEMPERATURE ZERO OR BELOW

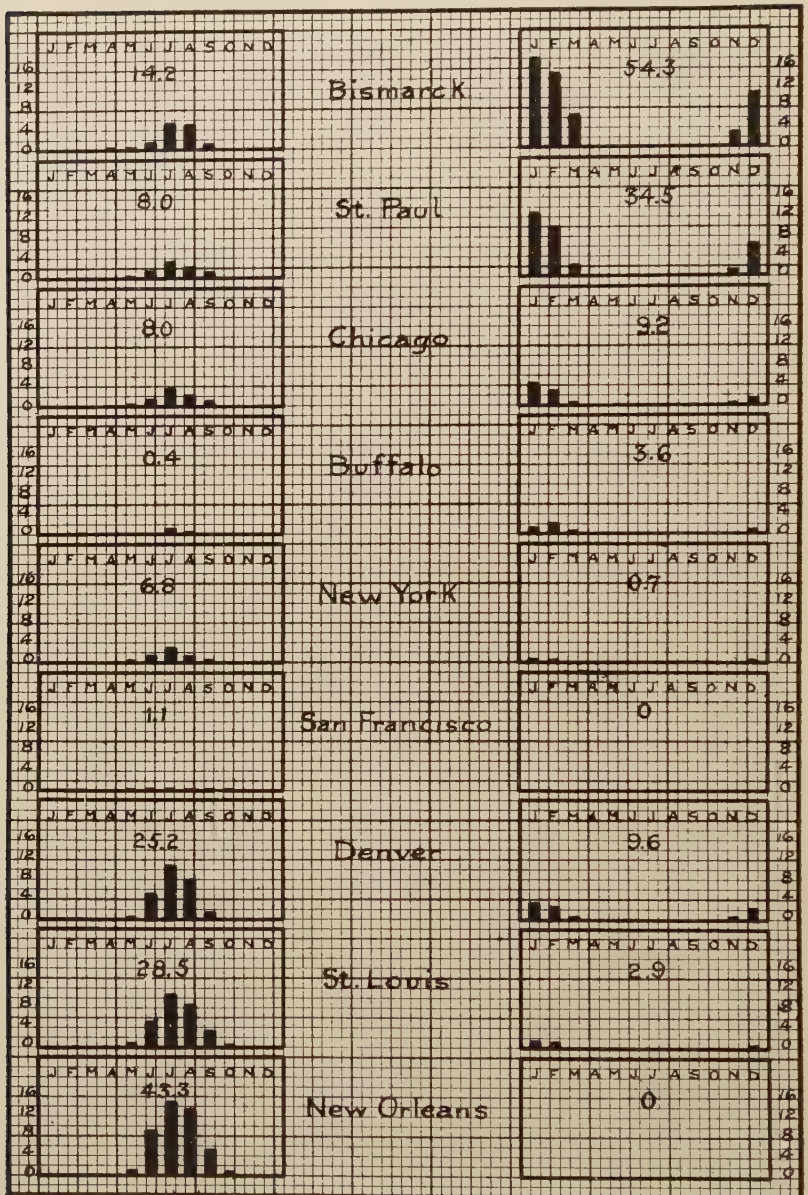
(These values are shown graphically in Fig. 6)

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Bismarck, N.D.	18.1	15.2	6.6	0	0	0	0	0	0	0	3.4	10.9	54.3
St. Paul, Minn.	13.1	10.3	2.4	0	0	0	0	0	0	0	1.6	6.4	34.5
Chicago, Ill.	4.1	3.1	0.2	0	0	0	0	0	0	0	0.1	1.6	9.2
Buffalo, N.Y.	1.2	2.0	0.1	0	0	0	0	0	0	0	0	0.3	3.6
New York, N.Y.	0.3	0.3	0	0	0	0	0	0	0	0	0	0.1	0.7
Denver, Colo.	3.7	2.7	0.5	0	0	0	0	0	0	0	0.6	2.3	9.6
St. Louis, Mo.	1.4	1.0	0	0	0	0	0	0	0	0	0	0.5	2.9

of 0.4 and 1.1 days, respectively, because their prevailing winds are from water surfaces. The great expanse of the Pacific Ocean protects San Francisco, in common with all other western coast cities, from the extreme rigors of the winter season, and it does not experience zero weather; and while New Orleans is too near the tropics to expect such conditions, it has experienced temperatures differing from zero by less than 10°.

ABSOLUTE MONTHLY MAXIMUM AND MINIMUM TEMPERATURES

We have now reached a point where greater details can be given regarding the temperature records of the Chicago Weather Bureau office. Tables XXV and XXVI give the highest maximum and lowest minimum temperature, respectively, occurring in each month



Average number of days with maximum temperature of 90° or more.

Average number of days with minimum temperature of zero or below.

Fig. 6.

of the year during the period of official record, and the annual values together with the mean annual temperatures are graphically portrayed

TABLE XXV

ABSOLUTE MONTHLY MAXIMUM TEMPERATURES, 1871-1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1871	62	56	67	80	84	87	92	90	87	75	61	45	92
1872	45	52	**45**	81	83	98	97	93	93	81	59	46	98
1873	51	53	60	83	87	92	93	92	88	75	59	60	93
1874	60	56	64	**67**	89	95	99	**98**	89	78	72	52	99
1875	44	45	73	72	79	89	88	86	87	73	57	**68**	**89**
1876	**65**	**63**	69	70	87	88	93	92	**78**	73	64	45	93
1877	56	58	65	78	86	87	91	89	86	80	58	67	91
1878	49	55	68	75	78	85	97	91	87	79	57	46	97
1879	49	51	71	80	87	87	93	91	83	84	69	62	93
1880	61	**63**	60	80	85	91	95	93	85	78	65	50	95
1881	41	51	48	77	87	89	93	**98**	94	77	64	59	98
1882	58	62	63	76	**76**	88	90	87	87	77	72	45	90
1883	40	57	62	78	80	**84**	91	89	84	78	62	57	91
1884	49	53	59	77	78	86	89	91	89	83	64	61	91
1885	50	47	58	76	80	88	94	**85**	81	**69**	66	50	94
1886	48	56	70	81	82	87	94	92	86	79	69	60	94
1887	52	58	68	82	86	96	100	**98**	92	82	67	53	100
1888	44	47	64	83	81	90	94	91	88	76	**75**	53	94
1889	55	48	68	73	88	86	90	88	84	79	57	64	90
1890	62	59	56	75	86	92	93	96	88	73	67	53	96
1891	54	58	57	75	81	88	**87**	96	91	86	60	57	96
1892	55	49	53	78	**76**	91	94	93	88	80	58	57	94
1893	46	46	69	84	83	85	94	95	95	81	67	58	95
1894	60	48	74	84	88	93	96	95	90	76	60	55	96
1895	51	61	80	81	**94**	95	92	93	92	71	67	56	95
1896	50	58	58	84	89	89	93	**98**	88	75	70	57	98
1897	57	44	58	78	81	93	95	90	94	**87**	66	57	95
1898	55	60	68	76	79	90	94	93	92	75	67	46	94
1899	48	49	64	**88**	83	90	90	91	**98**	84	63	56	98
1900	56	62	55	79	86	88	92	94	90	86	63	53	94
1901	54	**35**	68	83	87	97	**103**	90	87	85	66	57	**103**
1902	50	48	65	83	86	91	90	86	81	76	70	50	91
1903	51	49	74	78	85	90	92	92	86	83	63	**40**	92
1904	39	53	65	79	87	88	94	90	87	78	67	54	94
1905	48	47	75	77	84	91	95	92	86	83	69	52	95
1906	63	54	56	80	90	93	92	92	89	75	64	56	93
1907	59	53	80	70	83	91	90	92	92	81	**56**	58	92
1908	49	50	71	76	87	93	96	96	92	82	66	53	96
1909	**65**	57	55	74	86	87	92	93	89	76	71	55	93
1910	46	51	**81**	86	78	91	97	89	83	84	67	43	97
1911*	54	58	73	70	**94**	98	102	92	86	79	74	60	102
1912*	**38**	50	56	75	88	87	92	95	94	84	70	57	95
1913*	55	62	65	80	85	**99**	99	97	97	83	72	57	99
Means	52.4	53.0	64.6	78.4	84.0	90.0	94.4	91.8	87.9	78.8	64.6	54.2	94.5
Highest monthly maximum	65	63	81	88	94	99	103	98	98	87	75	68	103
Year	1876, 1909	1876, 1880	1910	1899	1895, 1911	1913	1901	1874, 1881, 1887, 1896	1899	1897	1888	1875	1901
Lowest monthly maximum	38	35	45	67	76	84	87	85	78	69	56	40	35
Year	1912	1901	1872	1874	1882, 1892	1883	1891	1885	1876	1885	1907	1903	1901

* Not included in means.

Highest and lowest maxima in bold-faced type.

in Fig. 7. Table XXV shows that on the average a maximum temperature of 90°0 is reached some time during the month of June, 94°4 during the month of July, and 91°8 during the month of August, and

in no other months does the temperature average to reach or exceed 90°. Table XXVI shows that on the average a minimum tempera-

TABLE XXVI

ABSOLUTE MONTHLY MINIMUM TEMPERATURES, 1871–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1871	10	6	**32**	**36**	38	**56**	59	54	40	26		− 8	− 8
1872	−12	− 2	8	27	38	51	52	56	37	28	**− 2**	**−23**	**−23**
1873	−16	−18	**−12**	25	35	44	**50**	53	41	23	8	13	−18
1874	− 6	9	17	22	38	46	60	58	44	30	0	1	− 6
1875	**−20**	−13	9	**17**	**27**	**40**	56	52	40	30	0	− 1	−20
1876	4	− 3	10	32	35	47	57	54	37	28	14	−14	−14
1877	− 4	**21**	5	27	33	45	57	55	44	35	14	**22**	− 4
1878	− 1	17	25	**36**	38	50	59	57	43	27	**31**	− 9	− 9
1879	−18	− 6	16	**17**	39	43	60	52	39	28	16	− 2	−18
1880	**19**	12	19	27	37	52	57	53	40	28	1	−15	−15
1881	−13	8	11	**17**	37	46	57	58	49	**41**	14	13	−13
1882	1	10	22	25	34	42	55	51	42	40	21	− 7	− 7
1883	−17	− 9	10	28	36	48	51	54	42	38	10	0	−17
1884	−18	− 3	− 1	31	40	47	54	51	51	28	5	−11	−18
1885	−13	−14	4	27	34	42	53	55	47	36	28	− 2	−14
1886	−14	− 6	15	23	40	49	55	53	42	32	16	−10	−14
1887	−15	− 7	9	19	42	48	61	**47**	38	**14**	− 1	− 5	−15
1888	−17	−18	− 1	30	32	43	56	51	36	32	20	15	−18
1889	0	−11	20	29	36	42	54	54	35	35	12	15	−11
1890	− 5	3	0	28	34	52	56	51	39	28	27	8	− 5
1891	10	− 8	7	23	35	44	55	49	48	33	3	9	− 8
1892	− 5	2	5	23	37	43	53	50	46	32	12	−10	−10
1893	−16	− 9	9	27	37	48	60	54	39	26	4	− 6	−16
1894	− 9	− 4	9	31	35	**40**	54	48	44	32	10	− 3	− 9
1895	− 9	−15	9	29	32	50	**50**	58	36	24	8	0	−15
1896	− 9	− 9	6	18	**46**	50	56	54	40	29	6	8	− 9
1897	**−20**	− 6	17	24	33	44	56	54	42	38	7	− 2	−20
1898	6	− 8	21	19	37	52	59	59	49	30	2	0	− 8
1899	−13	**−21**	3	18	42	49	59	63	**32**	36	30	− 3	−21
1900	− 8	− 9	− 1	28	36	48	55	**64**	41	**41**	14	2	− 9
1901	− 5	− 1	1	30	41	43	56	58	40	33	16	−12	−12
1902	− 8	− 7	3	23	36	48	54	55	42	35	26	− 1	− 8
1903	− 6	−11	13	28	33	44	59	55	40	33	12	−13	−13
1904	−15	− 6	13	23	38	48	53	55	47	34	19	2	−15
1905	− 5	−18	15	30	38	49	56	62	52	29	14	7	−18
1906	11	6	10	34	36	51	59	56	**55**	27	25	10	**6**
1907	− 3	− 2	23	23	34	47	55	54	39	35	25	19	− 3
1908	0	− 2	21	24	34	47	60	58	36	34	25	10	− 2
1909	−10	12	14	25	32	48	55	59	47	29	28	− 7	−10
1910	− 5	− 6	26	26	38	43	**62**	53	49	27	20	7	− 6
1911*	0	8	13	27	33	55	53	59	51	32	12	5	0
1912*	−16	− 7	6	31	39	49	57	55	39	38	25	3	−16
1913*	0	− 2	− 4	32	38	44	59	60	38	27	20	18	− 4
Means	− 6.8	− 3.9	11.0	25.7	36.3	46.7	56.1	54.7	42.2	31.1	13.7	− 0.1	−11.8
Lowest monthly minimum	−20	−21	−12	17	27	40	50	47	32	14	− 2	−23	−23
Year	1875, 1897	1899	1873	1875, 1879, 1881	1875	1875, 1894	1873, 1895	1887	1899	1887	1872	1872	1872
Highest monthly minimum	19	21	32	36	46	56	62	64	55	41	31	22	64
Year	1880	1877	1871	1871, 1878	1896	1871	1910	1900	1906	1881, 1900	1878	1877	1900

* Not included in means.
Highest and lowest minima in bold-faced type.

ture of −6°.8 is reached some time during the month of January, −3°.9 during the month of February, and −0°.1 during the month of December, and that the temperature does not average to fall with-

in 10° of zero in any other month. These statements must not be construed as contradictory in any sense to the discussion in connection with Tables X and XI (p. 25), and must be understood as

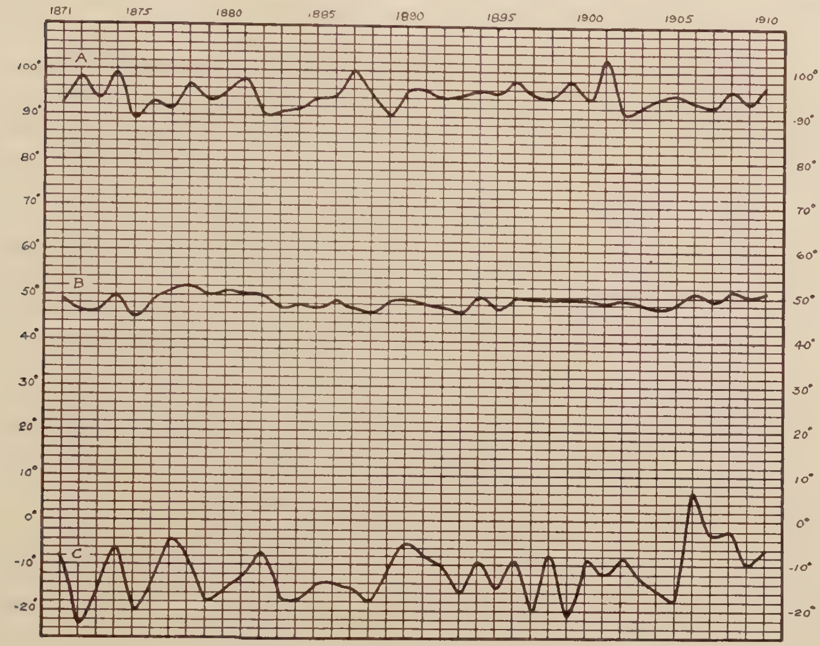


Fig. 7.

A=absolute annual maximum temperature; B=average annual temperature; C=absolute annual minimum temperature.

applying only to the absolute extremes of temperature for each month, whereas in the previous case the mean maximum and mean minimum temperatures were under consideration.

FREQUENCY OF DAYS WITH TEMPERATURE OF 90° OR OVER

Fig. 8 shows graphically the great variation in the frequency of high temperatures from one year to another, and the detailed data in Table XXVII supplement, as far as Chicago is concerned, the averages found in Table XXIII. While the temperature reaches 90° on an average of 8 times each year, it did not once reach 90° in 1875, the coldest year on record, and it reached it only once in 1882 and only once in 1884. The greatest number of times on which

90° or over has been reached, exclusive of 1911 and 1913, is 18 days in each of the years 1895 and 1900, although the monthly frequency in the two years was quite unequal. In 1895, of the 18 days, 4 occurred in May, 3 in June, 2 in July, 3 in August, and 6 in September; while in 1900, none occurred in either May or June, and there were 7 in July, 10 in August, and 1 in September. The year 1900 was on the whole warmer than the normal, with its August the warmest month of that name on record, but the year 1895 showed quite a deficiency in temperature. The averages of the monthly records in Table XXVII, however, give the greatest frequency for days with

TABLE XXVII

Number of Days with Maximum Temperature of 90° or Over, 1873–1913

(These values are shown graphically in Fig. 8)

Year	May	June	July	Aug.	Sept.	Annual	Year	May	June	July	Aug.	Sept.	Annual
1873....	......	2	2	3	......	7	1895....	4	3	2	3	6	18
1874....	......	5	6	6	......	17	1896....	......	0	5	6	......	11
1875....	......	0	0	0	......	0	1897....	......	2	4	1	5	12
1876....	......	0	6	1	......	7	1898....	......	1	6	4	3	14
1877....	......	0	2	0	......	2	1899....	......	2	1	2	3	8
1878....	......	0	3	1	......	4	1900....	......	0	7	10	1	18
1879....	......	0	6	1	......	7	1901....	......	4	11	1	......	16
1880....	......	1	4	1	......	6	1902....	......	1	2	0	......	3
1881....	......	0	5	5	2	12	1903....	......	1	7	2	......	10
1882....	......	0	1	0	......	1	1904....	......	0	3	1	......	4
1883....	......	0	4	0	......	4	1905....	......	3	3	3	......	9
1884....	......	0	0	1	......	1	1906....	1	3	1	4	......	9
1885....	......	0	4	0	......	4	1907....	......	1	1	1	1	4
1886....	......	0	3	1	......	4	1908....	......	2	3	4	4	13
1887....	......	2	5	3	1	11	1909....	......	0	3	2	......	5
1888....	......	1	4	1	......	6	1910....	......	3	6	0	......	9
1889....	......	0	2	0	......	2	1911*...	6	5	9	2	......	22
1890....	......	3	4	2	......	9	1912*...	......	0	3	3	5	11
1891....	......	0	0	3	2	5	1913*...	......	8	7	4	3	22
1892....	......	2	5	2	......	9							
1893....	......	0	6	1	2	9	Average..	0.1	1.2	3.8	2.1	0.8	8.0
1894....	......	5	6	3	1	15							

* Not included in averages. See note under Table XXXIX.

high temperatures to July, 3.8 days. August follows with 2.1 days, and June is next with 1.2 days; September averages 0.8 day, while 90° or over is comparatively rare during May, the average being but 0.1 day. By months, the greatest number of occurrences of 90° or over is as follows: May, 6 in 1911; June, 8 in 1913; July, 11 in 1901; August, 10 in 1900; and September, 6 in 1895. In 1878, one of the warmest years from the standpoint of the annual mean, there were but 4 days with a maximum temperature of 90° or over; while in 1901, a year slightly below normal, there were 16 such days, 4 occurring in June, 11 in July, and 1 in August. July of that year was the warmest month on record, and had the highest absolute maximum temperature ever officially observed at Chicago, 103°.

These variations with those noted above lead to the conclusion that some years are warmer than the average because of sustained moderate heat, while others are warmer because of the relative frequency of hot days. The year 1911 in Chicago was the warmest since the establishment of the Weather Bureau office, if we accept the Federal Building record without correction, and it was marked by an extraordinarily large number of hot days, 90° or over being reached 22 times, 4 days more than in either 1900 or 1905, although the number was equaled in 1913. Of these 22 days, 6 occurred in May, 5 in

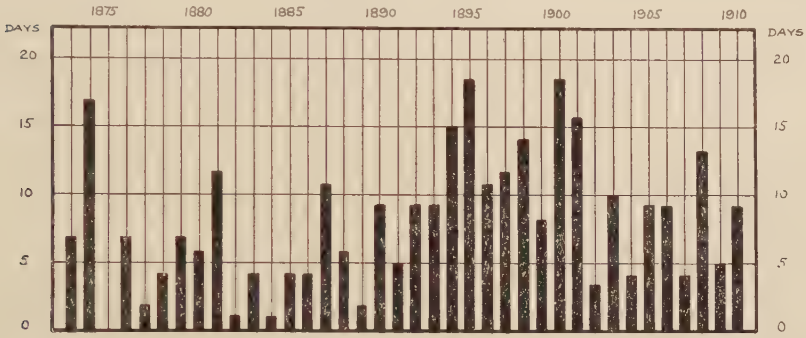


FIG. 8.—Annual number of days with maximum temperature of 90° or over (see Table XXVII).

June, 9 in July, and 2 in August, and May and June were the warmest of those months on record. In 1913, the occurrence was June, 8; July, 7; August, 4, and September, 3.

LONGEST PERIODS OF CONSECUTIVE DAYS WITH MAXIMUM TEMPERATURE OF 90° OR ABOVE

In addition to the relative annual and monthly frequency of hot days, it is important to secure an idea of the length of periods of such extreme conditions, and the longest of each year are shown in Table XXVIII. The average length is 2.8 days, and the longest period experienced is 8 days, from August 4 to 11, 1900, the absolute maximum during that time being 94°. There are several summers apparent in the table in which the temperature did not reach 90° on any two successive days. In fact, warm waves in Chicago are of such brief duration, being interrupted by changes to moderate and pleasant weather, that residences and other buildings seldom become heated to an uncomfortable degree when proper precautions

are exercised. It will be noted that by far the greater proportion of the periods recorded in Table XXVIII occurred either in July or August, 24 of the 31 occurring in these two months falling in July, and indicating a greater frequency of periods of extreme and sustained heat in that month.

On such days the temperature remains at 90° or over for a variable period, depending largely upon the absolute maximum. During the hot waves of July, 1901, and June–July, 1911, when the thermometer in Chicago passed the 100° mark, reaching 103° and 102°, respectively, the temperature remained at 90° or above for from 10 to 14 hours on

TABLE XXVIII

LONGEST PERIODS OF CONSECUTIVE DAYS WITH A MAXIMUM TEMPERATURE OF 90° OR ABOVE, 1873–1913

Year	Began	Ended	Length in Days	Temperature	Year	Began	Ended	Length in Days	Temperature
1873......	July 16	July 17	2	93	1895......	Sept. 19	Sept. 22	4	91
1874......	Aug. 19	Aug. 21	3	94	1896......	Aug. 8	Aug. 11	4	98
1875......	None occurred				1897......	July 2	July 4	3*	95
1876......	July 6	July 9	4	93	1898......	Sept. 1	Sept. 3	3	92
1877......	July 8	July 8	1	91	1899......	Sept. 5	Sept. 5	1*	98
1878......	July 16	July 17	2	97	1900......	Aug. 4	Aug. 11	8	94
1879......	July 14	July 16	3	93	1901......	July 20	July 21	2*	103
1880......	July 10	July 13	4	95	1902......	June 12	June 12	1*	91
1881......	July 7	July 9	3	93	1903......	July 1	July 4	4	92
1882......	July 27	July 27	1	90	1904......	July 16	July 18	3	94
1883......	July 2	July 4	3	91	1905......	July 16	July 18	3	95
1884......	Aug. 19	Aug. 19	1	91	1906......	Aug. 20	Aug. 22	3	92
1885......	July 19	July 20	2	94	1907......	Aug. 11	Aug. 11	1*	92
1886......	July 6	July 6	1*	94	1908......	Sept. 9	Sept. 11	3	92
1887......	July 15	July 17	3	100	1909......	July 28	July 29	2	92
1888......	July 30	July 31	2	94	1910......	July 24	July 26	3	97
1889......	July 8	July 9	2	90	1911......	June 30	July 5	6	102
1890......	June 28	June 30	3	92	1912†.....	Aug. 31	Sept. 1	2*	95
1891......	Aug. 7	Aug. 9	3	96	1913†.....	July 3	July 5	3	94
1892......	July 23	July 27	5	94					
1893......	July 12	July 14	3	92	Average....	....	....	2.8	94.0
1894......	June 21	June 23	3	93					

* Two periods of equal length; the period with the highest maximum temperature selected.
† Not included in averages.

each day, as shown in Auxiliary Table C, which gives the actual times and extent of the high temperatures. On July 4 and 5, 1911, the temperature remained above 90° for 14 hours each day, reaching a maximum of 102° at 4 P.M. on the 4th, and at 3 P.M. on the following day. On the 4th the last reading of 90° was at 11 P.M., the latest at night that this degree has occurred within the period of record, although on the 5th it continued as late as 10 P.M. In the morning 90° was reached exceptionally early during both hot waves: at 9 A.M. on July 21, 1901, and at the same hour on July 2 to 5, inclusive, 1911. Fortunately, such days are very rare in Chicago, and can happen only when conditions are unfavorable for the setting in of the lake breeze.

Extreme heat would occur in the city much more frequently were it not for this beneficent wind, and would often extend over a much longer period, as is the case in the interior sections away from the lake. In this connection it is interesting to note that on July 5, 1911, the last day of the second period shown in the table, the minimum temperature for the entire twenty-four hours was 82° at 5 A.M., the highest minimum ever recorded at the Chicago Weather Bureau office.

AUXILIARY TABLE C

LENGTH OF TIME WITH TEMPERATURE OF 90° OR OVER, DURING HOT WAVES OF 1901 AND 1911, CHICAGO

Date	From	To	Number of Hours	Max. Temp.	Time of Max.
July 20, 1901	12 NOON	7 P.M.	8	97	4, 5 P.M.
21, 1901*	9 A.M. 3 P.M.	1 P.M. 9 P.M.	12	103	5 P.M.
June 30, 1911	....	1 P.M.	1	90	1 P.M.
July 1, 1911	11 A.M.	8 P.M.	10	96	2, 3, 4 P.M.
2, 1911	9 A.M.	7 P.M.	11	98	4 P.M.
3, 1911†	.... 11 A.M.	9 A.M. 7 P.M.	10	100	3 P.M.
4, 1911‡	9 A.M. 10 P.M.	8 P.M. 11 P.M.	14	102	4 P.M.
5, 1911	9 A.M.	10 P.M.	14	102	3 P.M.

* On July 21, 1901, temperature fell to 84° between 1 and 3 P.M.

† On July 3, 1911, temperature fell to 88° between 9 and 11 A.M.

‡ On July 4, 1911, temperature fell to 89° between 8 and 10 P.M.

Indeed, on only two other days have minimum temperatures as high as 80° occurred, this mark being just reached on July 16 and 17, 1878, when the maximum readings were 97° amd 95°, respectively. Ordinarily, in hot-wave periods with daily maximum temperatures of 90° or over, the temperature falls below 80° for at least several hours during the night; and it has been found that the daily minimums in such conditions average about 73°2.

FREQUENCY OF DAYS WITH ZERO TEMPERATURES, MINIMUM AND MAXIMUM

Turning now from the consideration of conditions of extreme heat to those of extreme cold, Fig. 9 and Table XXIX give in detail data regarding the number of days, monthly and annually, of minimum temperatures of zero or below, and supplement for Chicago Fig. 6 and Table XXIV. The average number of such days occurring throughout the year is 9.2, distributed as follows: January, 4.1, February, 3.1, March, 0.2, November, 0.1, and December, 1.6 days. The time of greatest frequency is therefore during the month of January, with February following closely. One in about

every 8 days in January, and one in about every 10 days in February, are days on which the temperature reaches zero or goes below for some portion of the time, although the zero weather of February is

TABLE XXIX

Number of Days with Minimum Temperature of Zero or Below, 1873–1913

(These values shown graphically in Fig. 9)

Year	Jan.	Feb.	Mar.	Nov.	Dec.	Total	Year	Jan.	Feb.	Mar.	Nov.	Dec.	Total
1873	6	7	3	......	0	16	1895	7	8	......	......	1	16
1874	2	0	......	1	0	3	1896	3	3	......	......	0	6
1875	11	14	......	1	1	27	1897	6	1	......	......	3	10
1876	0	2	......	......	4	6	1898	0	3	......	......	1	4
1877	4	0	......	......	0	4	1899	6	8	......	......	2	16
1878	1	0	......	......	2	3	1900	4	5	2	......	0	11
1879	7	2	......	......	1	10	1901	1	2	......	......	7	10
1880	0	0	......	......	6	6	1902	3	5	......	......	1	9
1881	3	0	......	......	0	3	1903	4	3	......	......	7	14
1882	0	0	......	......	2	2	1904	5	5	......	......	0	10
1883	8	3	......	......	1	12	1905	6	9	......	......	0	15
1884	6	2	1	......	4	13	1906	0	0	......	......	0	0
1885	12	9	......	......	2	23	1907	2	3	......	......	0	5
1886	5	3	......	......	3	11	1908	1	1	......	......	0	2
1887	13	4	......	2	3	22	1909	2	0	......	......	3	5
1888	13	5	1	......	0	19	1910	2	2	......	......	0	4
1889	1	4	......	......	0	5	1911*	1	0	......	......	0	1
1890	1	0	2	......	0	3	1912*	13	3	......	......	0	16
1891	0	2	......	......	0	2	1913*	1	2	1	......	0	4
1892	3	0	......	......	3	6							
1893	10	3	......	......	4	17	Average	4.1	3.1	0.2	0.1	1.6	9.2
1894	2	1	......	......	1	4							

* Not included in average. See note under Table XL.

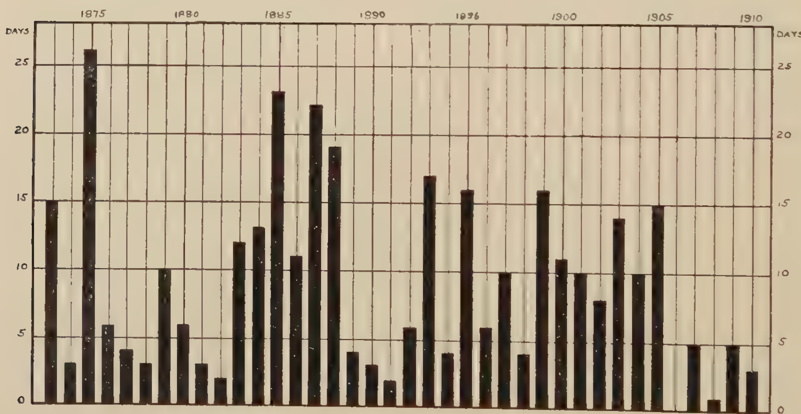


Fig. 9.—Annual number of days with minimum temperature of zero or below (see Table XXIX).

confined chiefly to the first half of that month. In 1875, the record-breaking year for cold weather, temperatures of zero or below occurred on 27 days, 11 of these being in January, 14 in February, and

1 each in November and December. On the other hand, in 1906 zero did not occur on any day of the year, and there are a number of years within the period of record in which zero was reached on less than 5 days. By months, February holds the individual record, zero or lower having occurred on 14 days in that month in 1875, as noted above, but January is really the month of greatest frequency, having 13 days in each of the years 1887, 1888, and 1912. In March, 1873, there were 3 such days; in November, 1887, 2, and in December, 1901 and 1903, 7 days each.

A day on which the minimum temperature reaches zero, or goes below it, marks, of course, severe winter weather in the city of Chicago, and it is but seldom that the mercury remains so low throughout the entire period of twenty-four hours. There have been a few instances of this kind, however, on which the maximum temperature for the day did not rise above the zero point, and these dates are set forth in Table XXX. Although the total number of such days

TABLE XXX

NUMBER OF DAYS WITH MAXIMUM TEMPERATURE OF ZERO OR BELOW, 1873–1913

Year	Jan.	Feb.	Dec.	Total	Year	Jan.	Feb.	Dec.	Total	Year	Jan.	Feb.	Dec.	Total
1873..	0	0	0	0	1888	1	1	0	2	1903	0	0	0	0
1874..	0	0	0	0	1889	0	1	0	1	1904	1	0	0	1
1875..	0	0	0	0	1890	0	0	0	0	1905	0	2	0	2
1876..	0	0	0	0	1891	0	0	0	0	1906	0	0	0	0
1877..	0	0	0	0	1892	0	0	0	0	1907	0	0	0	0
1878..	0	0	0	0	1893	3	1	0	4	1908	0	0	0	0
1879..	1	0	0	1	1894	0	0	0	0	1909	0	0	0	0
1880..	0	0	1	1	1895	1	1	0	2	1910	0	0	0	0
1881..	0	0	0	0	1896	0	0	0	0	1911	0	0	0	0
1882..	0	0	0	0	1897	2	0	0	2	1912	2	0	0	2
1883..	3	0	0	3	1898	0	0	0	0	1913	0	0	0	0
1884..	2	0	0	2	1899	0	2	0	2					
1885..	0	0	0	0	1900	0	0	0	0	Total	16	8	2	26
1886..	0	0	0	0	1901	0	0	1	1					
1887..	0	0	0	0	1902	0	0	0	0					

within the entire period of official record is only 26, the decidedly larger proportion, 16, have occurred in January, as was the case in the occurrence of zero minimum temperatures. Of the remaining cases, 8 occurred in February and 2 in December, which follow the order of frequency shown in the preceding table. No other months have been marked by such low maximum temperatures, and these 26 cases in the winter months were confined to 14 years. This would indicate a frequency of about one year in every three, but it will be noticed that in only 5 years has a single instance occurred, the other 9 years having 2, 3, or 4 each. January, 1883, and January, 1893,

had each 3 such days, but in no other individual month have there been more than 2.

LONGEST PERIODS OF CONSECUTIVE DAYS WITH TEMPERATURES OF ZERO OR BELOW

As is the case in regard to hot weather of the summer season (p. 71), a study of the frequency of severe cold weather during the opposite season must be incomplete unless an idea is gained relative to its length. Table XXXI gives the longest period in consecutive days for each of the fourteen years shown in Table XXX, when daily maximum temperatures of zero or lower were recorded. In only 5 of these years were there 2 or more consecutive days, and in only one year were there more than 2. This was in 1883, January 21 to 23, inclusive, during which time the temperature fluctuated between

TABLE XXXI

LONGEST PERIODS OF CONSECUTIVE DAYS WITH MAXIMUM TEMPERATURE OF ZERO OR BELOW, 1873–1913

Year	Began	Ended	Length	Lowest Maximum	Lowest Minimum	Year	Began	Ended	Length	Lowest Maximum	Lowest Minimum
1879...	Jan. 3	Jan. 3	1	0	−18	1895..	Jan. 27	Jan. 27	1†	−1	−9
1880...	Dec. 28	Dec. 28	1	−1	−12	1897..	Jan. 25	Jan. 26	2	−10	−20
1883...	Jan. 21	Jan. 23	3	−4	−17	1899..	Feb. 9	Feb. 10	2	−8	−21
1884...	Jan. 4	Jan. 5	2	−6	−18	1901..	Dec. 15	Dec. 15	1	−2	−12
1888...	Feb. 9	Feb. 9	1	−4	−18	1904..	Jan. 24	Jan. 24	1	−[illegible]	−13
1889...	Feb. 23	Feb. 23	1	−2	−11	1905..	Feb. 13	Feb. 13	1†	−4	−18
1893...	Jan. 15	Jan. 15	1*	−4	−16	1912..	Jan. 5	Jan. 6	2	−5	−11

* Also three other dates.

† Also one other date.

zero and −17°, not rising above −4° on either the 21st or 22d. While during the cold wave of January 25–26, 1897, the maximum temperature was below zero on but 2 days, the temperature did not rise above −10° on the 25th. This is the lowest maximum temperature on record at Chicago, and as the minimum on this day was −20°, the mean temperature for the day was −15°. January 25, 1897, therefore, as determined by its mean temperature, was the coldest day in Chicago during the history of the Weather Bureau office, although the absolute minimum was −23°, on December 24, 1872, with a mean temperature of −9°.

Table XXXII gives for each year the longest period of consecutive days with minimum temperature of zero or below. The feature of this table is the long period of 10 days extending from January 4 to January 13, 1912, which is 2 days longer than the next longest

period, in February, 1875. Both these months were the coldest of their respective names on record, the former having 13 days of zero temperature and the latter 14 (p. 75).

TABLE XXXII

Longest Periods of Consecutive Days with Minimum Temperature of Zero or Below, 1873–1913

Year	Began	Ended	Length	Lowest Temperature	Year	Began	Ended	Length	Lowest Temperature
1873......	Feb. 21	Feb. 25	5	−18	1894......	Jan. 24	Jan. 25	2	− 9
1874......	Jan. 14	Jan. 15	2	− 6	1895......	Feb. 7	Feb. 9	3	−15
1875......	Feb. 11	Feb. 18	8	−13	1896......	Feb. 19	Feb. 21	3*	− 9
1876......	Dec. 8	Dec. 10	3	−14	1897......	Jan. 24	Jan. 29	6	−20
1877......	Jan. 8	Jan. 9	2	− 3	1898......	Feb. 1	Feb. 3	3	− 8
1878......	Dec. 23	Dec. 24	2	− 9	1899......	Feb. 7	Feb. 13	7	−21
1879......	Jan. 2	Jan. 6	5	−18	1900......	Jan. 28	Feb. 1	5	− 8
1880......	Dec. 27	Dec. 31	5	−15	1901......	Dec. 18	Dec. 21	4	− 8
1881......	Jan. 14	Jan. 14	1*	−13	1902......	Feb. 2	Feb. 5	4	− 7
1882......	Dec. 7	Dec. 8	2	− 7	1903......	Jan. 10	Jan. 13	4	− 6
1883......	Jan. 19	Jan. 24	6	−17	1904......	Jan. 23	Jan. 25	3	−15
1884......	Jan. 3	Jan. 7	5	−18	1905......	Feb. 12	Feb. 16	5	−18
1885......	Jan. 17	Jan. 22	6	−13	1906†.....	....	....	....	....
1886......	Jan. 10	Jan. 12	3	− 9	1907......	Feb. 2	Feb. 4	3	− 2
1887......	Jan. 1	Jan. 3	3*	−15	1908......	Feb. 2	Feb. 2	1*	− 2
1888......	Jan. 11	Jan. 16	6	−17	1909......	Jan. 6	Jan. 7	2*	−10
1889......	Feb. 22	Feb. 24	3	−11	1910......	Jan. 6	Jan. 7	2*	− 5
1890......	Mar. 1	Mar. 2	2	0	1911......	Jan. 5	Jan. 5	1	0
1891......	Feb. 3	Feb. 4	2	− 8	1912......	Jan. 4	Jan. 13	10	−16
1892......	Dec. 25	Dec. 27	3	−10	1913......	Mar. 2	Mar. 2	1*	− 4
1893......	Jan. 13	Jan. 17	5	−16					

* Other periods of same length occurred during the year.

† No record of zero in 1906.

TABLE XXXIII

Longest Periods of Consecutive Hourly Temperatures, in Each Winter, of Zero or Below, 1890–91 to 1912–13

Season	From	To	Hours	Temperature
1890–91..............	8:00 P.M. Feb. 3	11:00 A.M. Feb. 4	16	− 6
1891–92..............	3:00 A.M. Jan. 9	10:00 A.M. Jan. 9	8	− 4
1892–93..............	6:00 A.M. Jan. 13	11:00 A.M. Jan. 16	78	−16
1893–94..............	9:00 A.M. Jan. 24	10:00 A.M. Jan. 25	26	− 9
1894–95..............	5:00 A.M. Feb. 7	10:00 A.M. Feb. 9	54	−15
1895–96..............	5:00 A.M. Feb. 19	10:00 A.M. Feb. 20	30	− 9
1896–97*.............	1:00 A.M. Jan. 24	10:00 A.M. Jan. 28	106	−20
1897–98..............	7:00 P.M. Feb. 2	8:00 A.M. Feb. 3	14	− 8
1898–99..............	1:00 A.M. Feb. 8	2:00 P.M. Feb. 11	86	−21
1899–1900............	6:00 A.M. Feb. 24	8:00 A.M. Feb. 25	27	− 9
1900–1901............	12:00 MDT. Dec. 31	10:00 A.M. Jan. 1	11	− 5
1901–2...............	2:00 A.M. Dec. 14	8:00 A.M. Dec. 16	55	−12
1902–3...............	12:00 MDT. Feb. 16	1:00 A.M. Feb. 18	26	−11
1903–4...............	10:00 P.M. Jan. 23	12:00 NOON Jan. 25	39	−15
1904–5...............	7:00 P.M. Feb. 1	9:00 A.M. Feb. 3	39	−14
1905–6†..............	....	....	....	....
1906–7...............	11:00 P.M. Jan. 25	9:00 A.M. Jan. 26	11	− 3
	11:00 P.M. Feb. 2	9:00 A.M. Feb. 3	11	− 2
1907–8...............	2:00 A.M. Feb. 2	8:00 A.M. Feb. 2	7	− 2
1908–9...............	2:00 A.M. Jan. 6	4:00 A.M. Jan. 7	27	−10
1909–10..............	11:00 P.M. Jan. 6	10:00 A.M. Jan. 7	12	− 5
1910–11†.............	6:00 A.M. Jan. 5	....	1	0
1911–12..............	4:00 P.M. Jan. 4	10:00 P.M. Jan. 7	79	−16
1912–13..............	4:00 A.M. Mar. 2	11:00 A.M. Mar. 2	8	− 4

* Temperature reached 1° above zero between hourly readings on the 27th.

† Zero temperature did not occur during periods for which no entries are made.

The preceding discussion has been confined to the length of cold periods by days. Since 1890, however, hourly temperature data are available, and from that date it is possible to record the actual number of hours in the longest periods of zero temperatures. This has been done by winters, and the results are presented in Table XXXIII. The longest period of this kind was in the winter of 1896–97, from 1 A.M. of January 24 to 10 A.M. of January 28, inclusive, extending over 106 hours, although once between the hourly readings on the 27th the thermometer indicated 1° above zero for a few minutes. The minimum during this period was −20°. The next longest period was 86 hours, in the cold February of 1899, with a minimum of −21°; and the third, 79 hours, during January, 1912, with a minimum of −16°.

OCCURRENCE OF FREEZING TEMPERATURE, SEASONAL

Between the conditions of extreme heat and extreme cold, marked usually by the limits of 90° and zero, respectively, there are certain other established degrees by which it is customary to characterize the temperature phases of a given period of time, and one of the more common of these is the freezing point, or 32°. Accordingly, around this point we have grouped several tables of data for the winter season, a study of which with their accompanying graphs will bring out still other features of the colder months than have yet been presented.

1. *Number of days with maximum temperature of 32° or below.*— The number of days in each winter season from October to April, inclusive, on which the temperature did not rise above the freezing point is shown by months in Table XXXIV, and Fig. 10 gives a graphic view of their seasonal frequency. Such days, on the average, appear to have been more frequent during the period from 1891 to 1905, during which time the Weather Bureau office was located at the Auditorium Tower, the average for the first 10 years of that period being much higher than that of any other decade, although there was but little difference in the mean temperatures, as shown by Table I. The mean daily maximum temperatures for the months of January and February, however, 31°.3 and 32°.7, respectively (Table X), are so near the freezing point that the average excess in temperature of the Federal Building, 1°.7, and of the Major Block, 0°.9 (p. 10), over that of the Auditorium, might be expected to show in a

relatively smaller number of days with maximum temperatures at 32° or below at those locations during the months in question. An

TABLE XXXIV

Number of Days with a Maximum Temperature of 32° or Below, October to April, 1871–1913

(These values, not including 1910–13, are shown graphically in Fig. 10)

Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	Season
1871–72	......	7	17	16	16	14	....	70
1872–73	......	9	18	18	7	5	....	57
1873–74	1	6	8	8	11	6	4	44
1874–75	......	3	22	20	20	12	2	79
1875–76	......	1	3	6	7	8	....	25
1876–77	......	2	22	15	0	13	....	52
1877–78	......	2	1	4	1	0	....	8
1878–79	......	0	15	17	11	2	1	46
1879–80	......	1	7	0	6	1	....	15
1880–81	......	10	11	21	14	3	1	60
1881–82	......	1	2	9	2	0	....	14
1882–83	......	0	12	20	13	6	....	51
1883–84	......	2	8	18	8	9	....	45
1884–85	......	2	10	18	18	7	....	55
1885–86	......	0	7	17	8	3	....	35
1886–87	......	3	13	19	11	6	....	52
1887–88	1	2	11	23	10	11	....	58
1888–89	......	1	6	11	16	2	....	36
1889–90	......	3	1	9	6	9	....	28
1890–91	......	0	10	9	9	10	2	40
1891–92	......	7	4	23	6	10	....	50
1892–93	......	5	16	28	17	8	1	75
1893–94	......	6	16	11	17	5	....	55
1894–95	......	6	9	22	20	8	....	65
1895–96	......	3	12	12	14	11	1	53
1896–97	......	5	8	16	10	5	....	44
1897–98	......	4	16	10	12	3	....	45
1898–99	......	6	13	15	17	10	3	64
1899–1900	......	0	13	8	17	9	....	47
1900–1901	......	2	8	17	26	5	....	58
1901–2	......	2	10	14	21	5	....	52
1902–3	......	0	13	18	13	1	....	45
1903–4	......	10	18	24	20	6	2	80
1904–5	......	2	19	24	20	4	....	69
1905–6	......	1	7	4	11	14	....	37
1906–7	......	0	6	13	10	0	....	29
1907–8	......	0	6	10	16	0	....	32
1908–9	......	1	6	11	6	2	....	26
1909–10	......	0	20	15	14	0	....	49
1910–11	......	4	16	10*	8*	2*	....	40
1911–12*	......	3	3	28	19	14	....	67
1912–13*	......	0	5	12	15	8	....	40
Means	0	3.0	11.0	14.7	12.3	6.0	0.4	47.3

* Not included in means.

SUMMARY OF TABLE XXXIV

Average Frequency of Days with a Maximum of 32° or Below

Decade	Nov.	Dec.	Jan.	Feb.	Mar.	Season
1871–72 to 1880–81	4.1	12.4	12.5	6.3	6.4	41.7
1881–82 to 1890–91	1.4	8.0	15.3	10.1	6.3	41.1
1891–92 to 1900–1901	4.4	11.5	16.2	15.6	7.4	55.1
1901–2 to 1910–11	2.0	12.1	14.3	13.9	3.4	45.7
1871–72 to 1909–10	3.0	11.0	14.7	12.3	6.0	47.3
Greatest number (1903–4)	10	18	24	20	6	80
Least number (1877–78)	2	1	4	1	0	8

examination of the table proves this to be the case, and the earlier and later months of the winter season do not present the same disproportion of occurrences at the different locations, because the mean maximum temperatures are then considerably higher than the freezing point.

The greatest number of such days occurring in any one season is 80, during 1903–4, and the next largest number, 79 in the season of 1874–75, while the least number is 8 in 1877–78. The greatest number in any one month is 28 in January, 1893, and also in January, 1912, while in January, 1880, and in February, 1877, there was not a single day on which the temperature did not exceed 32°. On the

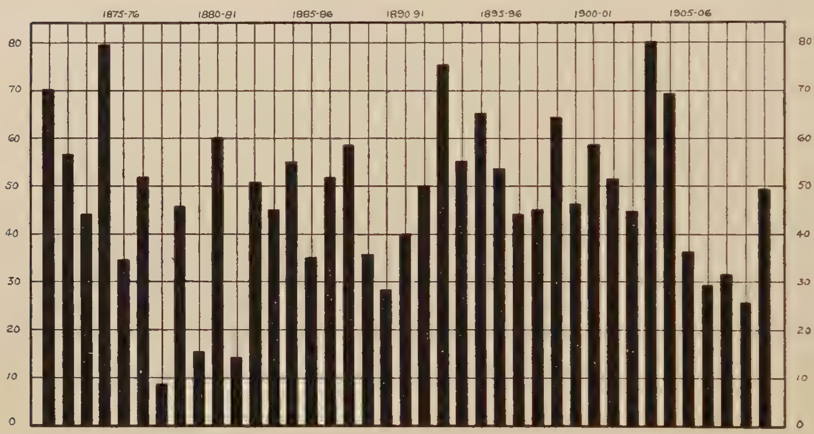


FIG. 10.—Number of days with a maximum temperature of 32° or below, October, 1871, to April, 1910 (see Table XXXIV).

average, the greatest frequency occurs in January, with a mean of 14.7 days. The averages of the entire winter season increase and decrease as follows: November, 3.0; December, 11.0; January, 14.7; February, 12.3; March, 6.0; April, 0.4 days. In October, throughout the whole period of record, the temperature remained at 32° or below in only two instances, once in 1873 and once in 1887, but the mean occurrence is too small to record.

2. *Longest periods of consecutive days with maximum temperature of 32° or below.*—Table XXXV will serve to supplement the discussion immediately preceding. The longest periods of the winter season during which the temperature remained at or below the freezing point

were those from December 18, 1878, to January 15, 1879, and from January 22 to February 19, 1895, and were of 29 days each. Several other periods of 20 days' length or over will be noted in the table, and with the exception of that in the extremely cold weather of January and February, 1912, all occurred during the occupancy by the Weather Bureau office of the Auditorium Tower. There were three winter seasons, 1877–78, 1879–80 and 1908–9, in which the maximum temperature did not remain below 32° for any period longer than 3 consecutive days. On the whole the temperature averages so as to remain at freezing or below for at least 12.6 consecutive days during the winter.

TABLE XXXV

LONGEST PERIODS OF CONSECUTIVE DAYS WITH MAXIMUM TEMPERATURE OF 32° OR BELOW, 1872–73 TO 1912–13

Winter	No. of Days	Time of Occurrence	Winter	No. of Days	Time of Occurrence
1872–73	15	Dec. 15–29	1894–95	29	Jan. 22–Feb. 19
1873–74	4	Jan. 30–Feb. 2	1895–96	6	Jan. 3–8, Feb. 16–21
1874–75	18	Jan. 3–20	1896–97	8	Jan. 23–30
1875–76	5	Mar. 17–21	1897–98	12	Dec. 17–28
1876–77	16	Dec. 16–31	1898–99	19	Jan. 27–Feb. 14
1877–78	3	Nov. 29–Dec. 1., Jan. 5–7	1899–1900	10	Dec. 25–Jan. 3
1878–79	29	Dec. 18–Jan. 15	1900–1901	23	Jan. 25–Feb. 16
1879–80	3	Feb. 3–5	1901–2	26	Jan. 27–Feb. 21
1880–81	7	Jan. 14–20	1902–3	10	Feb. 13–22
1881–82	6	Dec. 30–Jan. 4	1903–4	13	Jan. 23–Feb. 4
1882–83	13	Dec. 31–Jan. 12	1904–5	28	Jan. 22–Feb. 18
1883–84	11	Feb. 28–Mar. 9	1905–6	7	Mar. 11–17
1884–85	18	Feb. 6–23	1906–7	6	Jan. 25–30, Feb. 3–8
1885–86	8	Jan. 5–12, Jan. 29–Feb. 5	1907–8	7	Jan. 29–Feb. 4
1886–87	17	Dec. 27–Jan. 12	1908–9	3	Dec. 7–9, Jan. 11–13, Jan. 6–8, Jan. 30–Feb. 1, Feb. 14–16
1887–88	16	Jan. 14–29			
1888–89	5	Jan. 17–21, Feb. 5–9			
1889–90	5	Jan. 20–24, Mar. 4–8	1909–10	15	Dec. 17–31
1890–91	8	Feb. 25–Mar. 4	1910–11	5	Nov. 29–Dec. 3, Dec. 5–9
1891–92	20	Jan. 2–21	1911–12	21	Jan. 24–Feb. 13
1892–93	23	Jan. 1–23	1912–13*	10	Jan. 31–Feb. 9
1893–94	7	Feb. 10–16, Feb. 19–25			
			Average	12.6	

* Not included in means.

3. *Number of days with minimum temperature of 32° or below.*—The discussion of the two preceding topics has been confined to the days on which the temperature was at freezing or below during the entire twenty-four hours. It is useful also to know the frequency of days on which the lowest temperature touches or is below this point. Such days would, of course, include those shown in Table XXXV, but there would be many in addition on which the temperature was at freezing or below only a portion of the time. Table XXXVI and Fig. 11 give the data in the same manner as was done with the occurrence of a maximum of 32° or lower. It will be noted here also that

the Auditorium period of the record displays the greatest frequency, but the excess occurs chiefly in November, during the latter half of

TABLE XXXVI

Number of Days with a Minimum Temperature of 32° or Below, October to May, 1871–1913

(These values, not including 1910–13, are shown graphically in Fig. 11)

Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Season
1871–72	....	12	30	29	27	27	2	....	127
1872–73	3	17	31	30	28	24	11	....	144
1873–74	5	18	19	23	23	18	10	....	116
1874–75	1	14	25	30	28	21	8	1	128
1875–76	1	13	18	23	17	20	....	....	102
1876–77	1	11	30	28	12	28	2	....	112
1877–78	....	11	7	18	11	2	....	....	49
1878–79	3	1	25	27	26	11	3	....	96
1879–80	1	13	22	12	17	14	3	....	82
1880–81	2	20	27	31	27	28	8	....	143
1881–82	....	10	11	28	14	13	3	....	79
1882–83	....	10	26	31	26	26	3	....	122
1883–84	....	12	22	29	25	15	1	....	104
1884–85	1	9	20	28	26	25	4	....	113
1885–86	....	4	20	28	23	17	5	....	97
1886–87	....	16	27	30	28	27	6	....	134
1887–88	9	19	25	30	26	27	6	....	142
1888–89	1	7	24	28	27	11	1	....	99
1889–90	....	11	7	21	20	24	3	....	86
1890–91	2	7	25	25	23	24	5	....	111
1891–92	....	17	16	30	24	23	3	....	113
1892–93	....	21	29	31	27	22	4	1	134
1893–94	3	18	26	23	24	10	2	....	106
1894–95	1	22	22	31	24	25	5	....	135
1895–96	7	17	20	28	26	26	7	....	131
1896–97	4	18	18	28	26	19	4	....	117
1897–98	....	14	28	27	25	12	4	....	110
1898–99	1	13	28	27	24	29	5	....	126
1899–1900	....	1	22	23	27	30	5	....	108
1900–1901	....	15	24	30	28	22	1	....	120
1901–2	....	15	26	29	23	9	4	....	106
1902–3	....	6	25	29	23	11	3	....	97
1903–4	....	19	30	31	27	20	12	....	139
1904–5	....	8	30	30	27	18	4	....	117
1905–6	1	11	22	26	20	21	....	....	101
1906–7	2	8	24	24	24	14	11	....	107
1907–8	....	8	26	28	24	15	3	....	104
1908–9	....	9	25	22	20	19	3	1	99
1909–10	4	6	27	28	27	6	2	....	100
1910–11*	2	21	30	23	19	18	4	....	116
1911–12*	....	20	20	31	26	27	3	....	127
1912–13*	....	11	22	27	26	21	1	....	108
Means	1.4	12.5	23.2	27.0	23.7	18.8	4.2	0.1	111.7

* Not included in means.

SUMMARY OF TABLE XXXVI

Average Frequency of Days with a Minimum Temperature of 32° or Below (by Decades)

Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	Season
1871–72 to 1880–81	1.7	13.0	23.4	25.1	21.6	19.3	4.7	109.9
1881–82 to 1890–91	1.3	10.5	20.7	27.8	23.8	20.9	3.7	108.7
1891–92 to 1900–1901	1.6	15.6	23.3	27.8	25.5	21.8	4.0	120.0
1901–2 to 1910–11	0.9	11.1	26.5	27.0	23.4	15.1	4.6	108.6
1871–72 to 1910–11	1.4	12.5	23.2	27.0	23.7	18.8	4.2	111.7
Greatest number (1872–73)	3	17	31	30	28	24	11	144
Least number (1877–78)	....	11	7	18	11	2	....	49

which the mean daily minimum is very near the freezing point, and the influence of the various locations of the Weather Bureau office affects the occurrence at this time, just as was the case with the maximum temperatures of 32° or lower in January and February (p. 78). This excess is noticeable in March, as well, but not to so great an extent, as the mean daily minimum temperature, on account of the more rapid advance of the season in spring than in autumn (p. 26), is close to the freezing point for a much shorter interval than is the case in November. The excess shown in the month of February during the Auditorium Tower period, however, is due to really greater frequency in those years, as the average minimum temperature is well below 32° throughout the month.

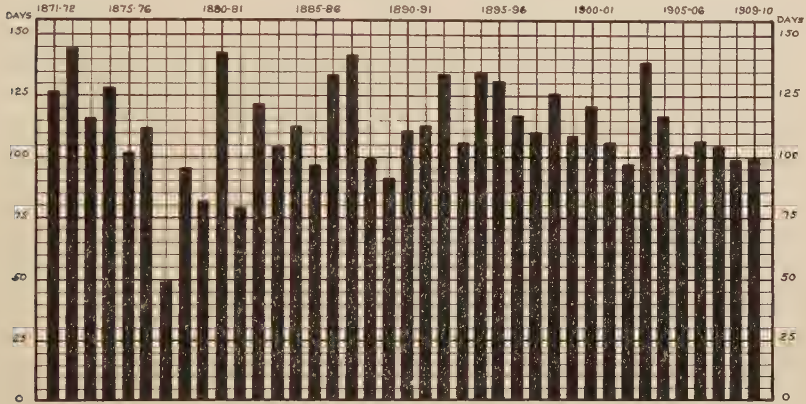


FIG. 11.—Number of days with a minimum temperature of 32° or below, from October, 1871, to May, 1910 (see Table XXXVI).

The average number of days from October to May on which the minimum temperature touches or goes below the freezing point, as shown by the table, is 112, but the actual frequency has varied greatly. In the season of 1872–73 there were as many as 144, while in that of 1877–78 there were only 49. The month of greatest frequency is, of course, January, with 27.0 days, followed in order by February, with 23.7, March with 18.8, April with 4.2, and May with 0.1 in the spring. In the first portion of the season, October averages 1.4 days, November 12.5, and December 23.2. In December, 1872, January, 1881, 1883, 1893, 1895, 1904, and 1912, and February, 1873, 1875, 1887, and 1901, the minimum temperature of every day reached 32° or lower; and in the three winter months of 1872–73

there was only one day on which the temperature remained above the freezing point. In the warm January of 1880 there were only 12 such days, and in February of 1878, only 11. There are several Aprils and Octobers apparent in the table in which freezing weather did not occur, but October, 1887, and April, 1904, were marked by an unusually large number, 9 and 12, respectively.

4. *Longest periods of consecutive days with minimum temperature of 32° or below.*—These periods, as shown in Table XXXVII and Fig. 12, include usually the longest intervals of maximum temperatures of

TABLE XXXVII

Longest Periods of Consecutive Days with Minimum Temperature of 32° or Below, 1872–73 to 1912–13

(These values, up to and including 1909–10, are shown graphically in Fig. 12)

Winter	No. of Days	Time of Occurrence	Winter	No. of Days	Time of Occurrence
1872–73	52	Nov. 25–Jan. 14	1894–95	65	Dec. 22–Feb. 24
1873–74	15	Jan. 28–Feb. 11	1895–96	29	Dec. 26–Jan. 23
1874–75	74	Dec. 28–Mar. 11	1896–97	61	Jan. 3–Mar. 4
1875–76	14	Jan. 23–Feb. 5	1897–98	27	Dec. 15–Jan. 10
1876–77	46	Dec. 14–Jan. 28	1898–99	26	Dec. 3–28, Jan. 22–Feb. 16
1877–78	11	Jan. 26–Feb. 5	1899–1900	52	Feb. 8–Mar. 31
1878–79	48	Dec. 10–Jan. 26	1900–1901	51	Jan. 16–Mar. 7
1879–80	24	Dec. 10–Jan. 2	1901–2	45	Jan. 10–Feb. 23
1880–81	56	Dec. 15–Feb. 8	1902–3	36	Dec. 22–Jan. 26
1881–82	15	Jan. 11–Jan. 25	1903–4	48	Dec. 20–Feb. 5
1882–83	49	Dec. 27–Feb. 13	1904–5	57	Jan. 2–Feb. 27
1883–84	28	Dec. 31–Jan. 27	1905–6	16	Mar. 10–25
1884–85	52	Jan. 7–Feb. 27	1906–7	28	Jan. 19–Feb. 15
1885–86	37	Jan. 4–Feb. 9	1907–8	20	Jan. 22–Feb. 10
1886–87	39	Dec. 14–Jan. 21	1908–9	16	Jan. 5–20
1887–88	42	Jan. 7–Feb. 17	1909–10	38	Dec. 5–Jan. 11
1888–89	30	Jan. 17–Feb. 15	1910–11	30	Nov. 28–Dec. 27
1889–90	13	Feb. 26–Mar. 10	1911–12	49	Dec. 31–Feb. 17
1890–91	18	Dec. 1–18, Jan. 2–19	1912–13*	31	Jan. 18–Feb. 17
1891–92	30	Jan. 2–31			
1892–93	68	Dec. 8–Feb. 13	Average	37.2	
1893–94	32	Nov. 13–Dec. 14			

* Not included in means.

32° or below which were presented in Table XXXV, as the minimum temperature at night ordinarily passes the freezing point for several days before and after a cold spell in which the maximum readings are below that point. The exceptions to this rule are confined to the shorter periods, as will be seen readily in the comparison of the two tables. On the average the temperature reaches the freezing point during the winter season for an interval of 37.2 consecutive days. That is, out of a total average seasonal number of 112 days with minimum temperature of 32° or below (Table XXXVI), about one-third occur consecutively at some time or other during the course of the winter; and these periods are about three times the length of the longest

intervals of temperature continuously below the freezing point (Table XXXV). From season to season there is considerable variation in the number of consecutive days with minimum temperature of 32° or lower, the largest number being 74, from December 28, 1874, to March 11, 1875; and the least, 11, from January 26 to February 5, 1878. The latter period occurred during the warmest winter season on record; but in the former case, while the winter of 1874–75 averaged considerably below normal, it was not by several instances the coldest winter within the period of official observations. In the very cold winter of 1892–93, whose mean temperature was 19°.0, the longest

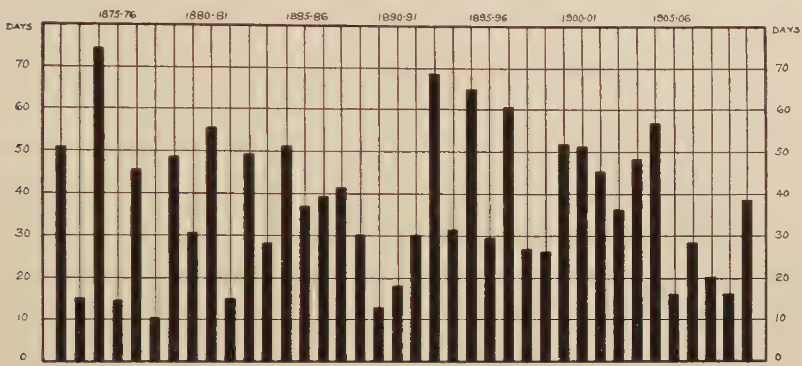


FIG. 12.—Longest period of consecutive days in each winter with a minimum temperature of 32° or below (see Table XXXVII).

period with minimums of 32° or below was 68 days, while in the still colder winter of 1903–4, whose mean temperature was 18°.3, the longest period was only 48 days. These seasons had 16 and 17 days with minimums of zero or below, and 4 and 1 days with maximums of zero or below, respectively (Tables XXIX and XXX). From such instances as those given in connection with the discussion of the present and previous topics, we must conclude that, analogous to the occurrence of years with an excess of heat (p. 71), some winters are below normal because of the relative frequency of severe days, and others because of a long continuance of moderately cold weather.

OCCURRENCE OF TEMPERATURES FAVORABLE TO PLANT GROWTH

The temperature of 42°.8 is one of the critical temperatures in the advancement of vegetation. There is very little plant growth below this temperature, but as soon as it is reached the various processes

of plant activity necessary to growth are begun and proceed more and more rapidly as the temperature rises, up to certain limits depending upon the character of the vegetation. Fig. 13 and the data given in Table XXXVIII show the number of days in each year since 1872 on which the mean temperature was above 42°. The average for the entire period is 221 days annually, but there is a rather wide range of fluctuation above and below this figure—from 249 days in 1878 to 198 days in 1873, which makes a difference of 51 days between the highest and lowest records. By referring to the tables of monthly mean temperatures (Tables I and III) it will be seen that the latter was an abnormally cold year, while the former was one of the warmest years within the period of observations. The table

TABLE XXXVIII

Annual Number of Days with Mean Temperature above 42°, 1872–1913

(These values, not including 1911–13, are graphically shown in Fig. 13)

Year	No. of Days	Year	No. of Days	Year	No. of Days	Year	No. of Days
1873	198	1884	230	1895	208	1906	221
1874	208	1885	213	1896	221	1907	215
1875	210	1886	231	1897	221	1908	236
1876	231	1887	206	1898	216	1909	232
1877	237	1888	210	1899	228	1910	223
1878	249	1889	222	1900	216	1911*	235
1879	235	1890	213	1901	210	1912*	221
1880	238	1891	210	1902	233	1913*	241
1881	218	1892	204	1903	222		
1882	236	1893	207	1904	213	Average	220.7
1883	223	1894	223	1905	218		

* Not included in averages.

Table XXXVIII shows the annual number of days with a mean temperature above 42°. The mean temperature of 42°.8 is the point above which temperatures are conducive to plant growth, and below which very little growth takes place.

includes all days of mean temperature of more than 42°, no matter in what portion of the year such days occur, and, of course, some proportion of them happen in the colder season, even in the months of January and February. However, the average number, 221 days, may be taken to represent the extreme length of the interval each year, other things being favorable, during which effective plant growth may take place. In Table XII it will be noted that the first occurrence of a daily mean temperature of 42°.8 is on April 4, the last on November 10, and that all temperatures between are higher than the critical temperature of 42°.8, and all recorded prior to the first and after the last are below that point. The interval from April 4 to November 10, inclusive, is exactly 221 days. So far as the growth

of annuals is concerned, however, a period of such length is seldom experienced in Chicago, as the season for such plants is materially shortened in most years by the occurrence of minimum temperatures below freezing, or sufficiently low to permit the formation of damaging frosts (Tables XLV, XLVI, and XLVII). In latitudes farther north the average number of days with mean temperature above 42° is considerably less than it is in this city, but the hours during which the sun shines through the summer days are correspondingly more, so that as a result the amount of heat necessary for the proper maturing of the crops of such regions is received. However, crops accli-

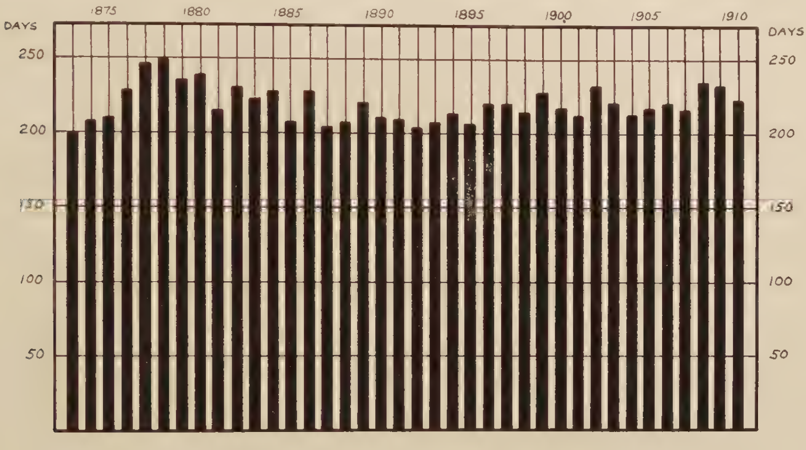


FIG. 13.—Annual number of days with mean temperature above 42°.

Fig. 13 shows the total annual number of days having a mean temperature above 42°, the degree of heat which marks the beginning of plant growth (see Table XXXVIII).

mated to northern latitudes require in maturing a less amount of heat than do those of similar character accustomed to regions farther south.

LIST OF WARM DAYS

The frequency of days with a maximum temperature of 90° or over has already been discussed (p. 69), so that no great enlargement on the list presented in Table XXXIX is necessary. The table serves the purpose of setting out sharply the various periods of hot weather which the city has experienced, and conveys in addition a general idea of the intensity of each. The figures show the absolute maximums for the days against which the entries are made, and may therefore be used also in connection with Table XLIII, in the study of daily extremes of temperature.

TABLE XXXIX

LIST OF WARM DAYS—MAY, 1873–1913

(Temperatures of 90° or above)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1895....	....	....	....	....	....	....	....	....	90	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	93	91	94	4
1906....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	90	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1
1911....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	90	92	91	....	....	....	....	....	94	94	94	....	....	....	....	6
																																11

See note at foot of table, p. 92.

TABLE XXXIX—*Continued*

LIST OF WARM DAYS—JUNE, 1873-1913

(Temperatures of 90° or above)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1873																			91				92									2
1874								90														90	94				95	93				5
1875																																0
1876																																0
1877																																0
1878																																0
1879																																0
1880											91																					1
1881																																0
1882																																0
1883																																0
1884																																0
1885																																0
1886																																0
1887																91	96															2
1888																				90												1
1889																																0
1890																												92	90	90		3
1891																																0
1892												90				91																2
1893																																0
1894															90						91	93	92						92			5
1895		92	95																						93							3
1896																																0
1897													90		93																	2
1898																													90			1
1899				90															90													2
1900																																0
1901																								93	93			93		97		4
1902												91																				1
1903																														90		1
1904																																0
1905					90	91											90															3
1906						91																						93	92			3
1907																	91															1
1908																						93	90									2
1909																																0
1910																	91	90											91			3
1911				95					98	98												93	94							90		6
1912																																0
1913						91									94	98			95							91	96		90	99		8
																																61

TABLE XXXIX—*Continued*

List of Warm Days—July, 1873–1913

(Temperatures of 90° or above)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1873																93	90															2
1874			94			99	97							93					92						98							6
1875																																0
1876						90	93	93	93								90		91													6
1877								91							90																	2
1878																97	95			90												3
1879			90							92	90			91	93	90																6
1880										92	91	93	95																			4
1881					92		92	92	93			92																				5
1882																											90					1
1883		90	91	90																		90										4
1884																																0
1885								90											92	94								92				4
1886						94																			90			94				3
1887												96			96	100	100										94					5
1888			91			90																								92	94	4
1889								90	90																							2
1890							93							90															91	92		4
1891																																0
1892																							92	91	94	93	92					5
1893							94					90	92	92										94	91							6
1894											92	93						90	92					96			93					6
1895														91		92																2
1896												91	92	93												91			92			5
1897		91	95	94																										91		4
1898	92	91														91			94								90	91				6
1899																										90						1
1900		91	90	91	91	91								92	90																	7
1901	92			95	91					102						92	92			97	103			94			95	90				11
1902																										90				90		2
1903	92	90	91	91				92	90																90							7
1904																90	94	92														3
1905																93	94	95														3
1906																						92										1
1907																					90											1
1908						92					96		91																			3
1909		91																										90	92			3
1910	92							94	94															97	92	95						6
1911	96	98	100	102	102			90	94	91					91																	9
1912					92				91															92								3
1913			94	94	92								92			92											94		99			7
																																162

TABLE XXXIX—*Continued*

List of Warm Days—August, 1873-1913

(Temperatures of 90° or above)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1873																						90		92							92	3
1874											98			90			91		93	94	91											6
1875																																0
1876																							92									1
1877																																0
1878								91																								1
1879		91																														1
1880																		93														1
1881			94	98							91	91																		90		5
1882																																0
1883																																0
1884																			91													1
1885																																0
1886																					92											1
1887			95						90	98																						3
1888			91																													1
1889																																0
1890		96	95																													2
1891							91	94	96																							3
1892								93	92																							2
1893										95																						1
1894	93						92	95																								3
1895									91	92				93																		3
1896				94	95			98	93	93	92																					6
1897																												90				1
1898																						90	93							90	90	4
1899										91										90												2
1900				94	94	93	92	92	94	94	91							93		92												10
1901									90																							1
1902																																0
1903																							90	92								2
1904																					90											1
1905					90				91			92																				3
1906			90																	91	91	92										4
1907											92																					1
1908			96	94												94															92	4
1909								93																91								2
1910																																0
1911							92		90					90		92																4
1912																	90							90	90						95	4
1913			95					94	97							93																4
																																91

TABLE XXXIX—*Continued*

LIST OF WARM DAYS—SEPTEMBER, 1873-1913

(Temperatures of 90° or above)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1881					94	93																										2
1887						92																										1
1891																	90							91								2
1893				91										95																		2
1894		90																														1
1895										91	92								91	91	90	90										6
1897								92	94	94				91	91																	5
1898	90	91	92																													3
1899		92			98		95																									3
1900										90																						1
1907	92																															1
1908									90	91	92							90														4
1912	93				94	94			91	93																						5
1913	95	97					93																									3
																																39

Table XXXIX contains a complete list of days from 1873 to 1913 during which the temperature rose to 90° or above, together with the maximum temperature reached on such days and the monthly frequency of occurrence. The figures in this table are entered to the nearest whole degree, while in Table XXVII the entries are made to the nearest enth of a degree. Temperature of 90° or above did not occur in years omitted from May and September lists.

LISTS OF COLD DAYS

The list of cold days with minimum temperatures of zero or lower, as set forth in Table XL, bears the same relation to the discussion of the frequency of such days (p. 73) that Table XXXIX of the previous paragraph does to that of the occurrence of hot days. This list covers the cold days of December, January, and February. In order to extend the record over the periods of severe weather in the early spring and late autumn months, however, it was necessary to use different limiting temperatures. Zero represents roughly a point about 25° below the daily mean temperatures of the winter season, and this difference makes the approximate measure of a cold day in March and November, 10° or below, and of a cold day in April and October, 24° or below, which are respectively the bases used in Tables XLI and XLII. The entries are in all cases the absolute minimum temperatures for the days in question and may be used in the study of the following subject.

DAILY EXTREMES OF TEMPERATURE, ABSOLUTE

Table XLIII contains the highest and lowest temperatures as recorded for each of the days of the year, the year of such record being given in each case, and the absolute range for the day. The table will be found useful in locating the earliest and latest occurrence of any given temperature, and the interval through which any given extreme has been reached or exceeded. For instance, it will be seen readily that the occurrence of a temperature of 100° or over has in all cases been confined to the first three weeks in July. The highest temperature ever recorded in this city by the official instruments was 103° on July 21, 1901. Other records of 100° or over are as follows: 102° on July 10, 1901, and on July 4 and 5, 1911; 100° on July 3, 1911, and on July 16 and 17, 1887. A temperature of 90° has occurred as early as May 9, and as late as September 24, in 1895 and 1891, respectively. The earliest protracted periods of 90° or over occurred from May 17 to 19, and from May 25 to 27, 1911; the latest was from September 19 to 22, 1895, during one of the warmest Septembers on record. This September had in all 6 days with readings of 90° or over, while there were but 3 in the preceding August, and 2 in July (Table XXXIX). In fact, the most pronounced hot weather of the year 1895 occurred, not in the summer, so much as in the late spring and early autumn. The temperature

TABLE XL

LIST OF COLD DAYS—DECEMBER, 1872–1913

(Temperatures of zero or below)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1872																					−12	−21	−18	−23			0					5
1875																	− 1															1
1876								−5	−14	0						− 8																4
1878																							− 3	− 9								2
1879																										− 2						1
1880									− 2																		− 7	−12	−15	0	− 1	6
1882							− 6	− 7																								2
1883																			0													1
1884																	− 1	− 9	−11				− 1									4
1885						0	− 3																									2
1886	− 4																										−10	− 1				3
1887																												− 4	− 5	0		3
1892																									− 2	−10	− 2					3
1893	− 6	− 1		0									− 1																			4
1894																												− 3				1
1895			0																													1
1897																		− 2					− 1	− 1								3
1898																															0	1
1899																														− 3	− 1	2
1901														− 9	−12	− 5		− 1	− 5	− 8	− 2											7
1902								− 1																								1
1903													−13	− 6	− 2										− 2	−10			0	− 4		7
1909																		− 1											− 2	− 7		3
																																67

See note at foot of table, p. 96.

TABLE XI—*Continued*

LIST OF COLD DAYS—JANUARY, 1873–1913

(Temperatures of zero or below)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1873									-8	-7							-4											-5	-16	-3		6
1874														0	-6																	2
1875				0	-7			-11	-20	-3				-8	-9		-1		-4						0						-7	11
1877								-3	-3				-1										-4									4
1878							-1																									1
1879		-16	-18	-8	-11	-1			0										-2													7
1881										-10				-13														-2				3
1883									-2					-2					0	-4	-15	-17	-14	-1								8
1884			-6	-14	-18	-14	-3													0												6
1885		-2											-3				-2	-6	-13	-7	-8	-12				-5	-2	-11	-4			12
1886										-8	-9	-7										-11	-14									5
1887	-6	-13	-15		-3	-10	-15			-10	-11						-2	-9	-8											-4	-8	13
1888		-1	0								-11	-4	-9	-11	-14	-17		-6	-1	-4	-12					-1						13
1889																					0											1
1890																						-5										1
1892							0		-5						0																	3
1893			-3			0				-9	-7		-8	-9	-16	-8	-8		-1													10
1894																								-3	-9							2
1895				-3								-9												-2			-9	-9		-8	0	7
1896			-4	-9	-3																											3
1897																								-15	-20	-16	-5	-3	0			6
1899	0																										-2	-6	-13	-10	-12	6
1900																												-3	-1	-4	-8	4
1901	-5																															1
1902																										-2	-8	-4				3
1903										0	-4	-6	0																			4
1904			-1																				-2	-13	-15		-6					5
1905									-1	-5				-5	-5									-2	0							6
1907																									-1	-3						2
1908																													0			1
1909						-10	-3																									2
1910						-4	-5																									2
1911					0																											1
1912				-6	-10	-11	-16	-3	-4	-6	-3	-3	-1		-2	-2			0													13
1913												0																				1
																																175

See note at foot of table, p. 96.

TABLE XL—*Continued*

LIST OF COLD DAYS—FEBRUARY, 1873-1913

(Temperatures of zero or below)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1873	0	-12																			-11	-14	-18	-11	-3							7
1875			-2	-10	-1	-1	-10	-7			-5	-13	-1	-1	-9	-6	0	0														14
1876		-3		0																												2
1879														-2													-6					2
1883	-9			-1	-7																											3
1884																												0	-3			2
1885										-14	-14	-6	-10			-10	-7		-2	-6	-1											9
1886		-6	-6		-1																											3
1887	0			-7								-3	0																			4
1888								-13	-18	-12																-1	-4					5
1889																				-2		-5	-11	-8								4
1891			-2	-8																												2
1893				-8			-9	-8																								3
1894																					-4											1
1895	-3	-9		-13	-15		-5	-15	-8		-6																					8
1896																			-6	-9	-3											3
1897																											-6					1
1898	-3	-5	-8																													3
1899				0			-5	-17	-21	-18	-7	-17	-5																			8
1900	-8															-5	-5							-9	-9							5
1901						-1																-1										2
1902		-3	-5	-6	-7			0																								5
1903																	-11	-9	-2													3
1904	-6			-4											-2	-4						0										5
1905	-11	-14	-10							-5		-4	-18	-11	-9	-1																9
1907		-1	-2	-2																												3
1908		-2																														1
1910																							-6	0								2
1912			-5	-7					-2																							3
1913	-1				-2							0																				3
																																125

Table XL contains a complete list of days from December, 1872 to 1913, for December, January, and February, during which a temperature of zero or below occurred, together with the minimum temperature reached on such days and the monthly frequency of occurrence. Temperatures of zero or below occurred in the months of November and March during but three and five years, respectively, and the dates of such occurrences will be found in Table XLI. The figures in this table are entered to the nearest whole degree, while in Table XXIX the entries are made to the nearest tenth of a degree. Temperature of zero or below did not occur in years omitted from the list.

TABLE XLI

List of Cold Days—November, 1872-1913

(Temperatures of 10° or below)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1872....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	9	....	....	....	....	....	....	3	0	−2	4	....	5
1873....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8	....	....	....	....	....	....	....	....	....	....	....	1
1874....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	....	1
1875....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	....	....	1
1880....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8	8	....	....	1	4	....	....	....	....	....	....	....	....	....	4
1883....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1
1884....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5	....	....	....	....	....	....	....	1
1887....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	0	−1	8	....	4
1891....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8	9	....	....	....	....	....	....	....	....	....	7	3	8	....	5
1893....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4	7	....	....	....	....	....	....	2
1894....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10	....	....	....	....	....	....	....	....	....	....	....	....	1
1895....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10	8	....	....	....	....	2
1896....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8	8	6	....	3
1897....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7	10	....	2
1898....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10	9	....	2	....	....	....	....	....	3
																																36

See note at foot of table, p. 98.

TABLE XLI—*Continued*

LIST OF COLD DAYS—MARCH, 1873–1913

(Temperatures of 10° or below)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1873	10		−6	−12	0																					7						5
1875				10													9															2
1876																		10														1
1877				5	10	9			9	6					6																	6
1883							10																									1
1884		6	8	−1																												3
1885																10	6		9	4	9											5
1888																					9	−1	10									3
1890	0	0			6	7									6																	5
1891	9			7										7																		3
1892										5				9																		2
1893															9																	1
1894																										9						1
1895														9																		1
1896												6	6																			2
1899						4	3																									2
1900																−1	−1															2
1901					1	3																										2
1902																	3															1
1906																						10										1
1912	6	6																														2
1913		−4																														1
																																52

Table XLI contains a complete list of days from November, 1872 to 1913, for the months of March and November, during which a temperature of 10° or below occurred, together with the minimum temperature reached on such days and the monthly frequency of occurrence. Temperature of 10° or below did not occur in years omitted from the list.

TABLE XLII

List of Cold Days—April, 1873–1913

(Temperatures of 24° or below)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1874	22		23	23	24																											4
1875																18	17	23														3
1879		24	17																													2
1881	17	20		19	19	21																										5
1886		23																														1
1887				23	19																											2
1891				23																												1
1892									23																							1
1896		18																														1
1897																				24												1
1898					19																											1
1899	22	18																														2
1902							23																									1
1904																23																1
1907														23																		1
1908		24																														1
																																28

See note at foot of table, p. 100.

TABLE XLII—*Continued*

LIST OF COLD DAYS—OCTOBER, 1872–1913

(Temperatures of 24° or below)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1873....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	23	1
1887....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	23	14	22	....	....	....	23	....	4
1895....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	24	....	....	....	....	....	....	....	24	24	....	....	3
																																8

Table XLII contains a complete list of days from October, 1872 to 1913, for the months of April and October, during which a temperature of 24° or below occurred, together with the minimum temperature on such dates and the monthly frequency. Temperature of 24° or below did not occur in years omitted from this table.

of 80° has been experienced as early as March 23 (1907), and as late as October 23 (1899 and 1901), when the maximum for each day was 82°. The earliest occurrence of 70° or over is March 8 (1879), and the latest is November 21 (1913), when the maximum was 72°.

The freezing point, 32°, has occurred as early as September 30 (1899), and as late as May 14 (1895); zero, as early as November 28 (1872 and 1887), and as late as March 22 (1888). The absolute minimum for the city is −23°, which occurred on December 24, 1872,

TABLE XLIII

Daily Extremes of Temperature, 1872–1913

	January					February					March				
	Max.	Year	Min.	Year	Extreme Range	Max.	Year	Min.	Year	Extreme Range	Max.	Year	Min.	Year	Extreme Range
1..	65	1876	−6	1887	71	55	1877	−11	1905	66	60	1882	0	1890	60
2..	57	1897	−16	1879	73	48	1877	−14	1905	62	61	1878	−4	1913	65
3..	60	1874	−18	1879	78	47	1882, 1885	−10	1905	57	64	1894	−6	1873	70
4..	59	1880	−14	1884	73	59	1890	−13	1895	72	60	1894	−12	1873	72
5..	56	1890	−18	1884	74	53	1909	−15	1895	68	66	1894	0	1873	66
6..	54	1907	−14	1884	68	57	1882	−1	1875, 1901	58	66	1876	3	1901	63
7..	59	1907	−16	1912	75	53	1882	−10	1875	63	60	1876	3	1899	57
8..	56	1876	−11	1875	67	62	1900	−17	1899	79	71	1879	14	1899	57
9..	60	1880	−20	1875	80	56	1886	−21	1899	77	66	1879	9	1877	57
10..	46	1880	−10	1881, 1887	56	63	1876	−18	1899	81	69	1876, 1879	5	1892	64
11..	61	1880	−11	1887, 1888	72	60	1876	−14	1885	74	65	1902, 1911	11	1892	54
12..	62	1890	−9	1895	71	62	1882	−17	1899	79	68	1887	6	1896	62
13..	47	1894	−9	1888	56	60	1882	−18	1905	78	60	1893, 1903, 1913	6	1896	54
14..	48	1894	−13	1881	61	58	1887	−11	1905	69	63	1913	7	1891	56
15..	53	1906	−16	1893	69	58	1882	−9	1875, 1905	67	62	1878, 1889	6	1877, 1890	56
16..	55	1889	−17	1888	72	57	1880, 1883	−10	1885	67	68	1889, 1898	−1	1900	69
17..	60	1894	−8	1893	68	60	1880	−11	1903	71	74	1894	−1	1900	75
18..	55	1880	−9	1887	64	58	1877	−9	1903	67	74	1903	10	1876	64
19..	55	1907	−13	1885	68	62	1913	−6	1896	68	73	1903	9	1885	64
20..	63	1906	−7	1885	70	54	1906	−9	1896	63	64	1886	4	1885	60
21..	62	1906	−15	1883	77	57	1877	−11	1873	68	76	1907	9	1885, 1888	67
22..	59	1909	−17	1883	76	58	1877	−14	1873	72	71	1907	−1	1888	72
23..	65	1909	−14	1883, 1887	79	53	1891	−18	1873	71	80	1907	10	1888	70
24..	62	1909	−15	1897	77	58	1891	−11	1873	69	79	1910	17	1874, 1899	62
25..	51	1880	−20	1897	71	57	1880	−9	1900	66	72	1907	13	1894	59
26..	58	1882	−16	1897	74	63	1880	−1	1888	64	71	1908	7	1873	64
27..	53	1911	−9	1895	62	58	1896	−6	1879, 1897	64	81	1910	15	1873	66
28..	60	1876	−11	1885	71	61	1895	0	1884	61	75	1905	9	1887	66
29..	51	1903	−16	1873	67	38*	1888	−3	1884	41	80	1895	9	1887	71
30..	50	1877, 1896, 1913	−10	1899	60	......	......	......	......	......	76	1910	16	1887	60
31..	56	1877	−12	1899	68	......	......	......	......	......	69	1893	21	1899	48

* 8 years.

TABLE XLIII—*Continued*

DAILY EXTREMES OF TEMPERATURE, 1872–1913

	April					May					June				
	Max.	Year	Min.	Year	Extreme Range	Max.	Year	Min.	Year	Extreme Range	Max.	Year	Min.	Year	Extreme Range
1..	73	1882	17	1881	56	85	1887, 1901	32	1888, 1909	53	85	1895	42	1882, 1889	43
2..	77	1903	18	1896, 1899	59	87	1901	27	1875	60	92	1895	43	1879, 1888, 1910	49
3..	73	1887	17	1879	56	87	1895	34	1907	53	95	1895	43	1910	52
4..	77	1873	19	1881	58	84	1895, 1905	35	1891, 1907	49	95	1911	44	1891	51
5..	83	1873	19	1881, 1887, 1898	64	86	1909	36	1890, 1891	50	90	1905	41	1894	49
6..	76	1882	21	1881	55	85	1889	35	1875, 1890	50	91	1905, 1906, 1913	40	1894	51
7..	84	1893	23	1902	61	85	1880	34	1885	51	89	1896	44	1894, 1913	45
8..	75	1910	26	1902	49	88	1889	37	1885	51	90	1874	42	1885	48
9..	80	1887	23	1892	57	90	1895	35	1885	55	98	1911	43	1901	55
10..	78	1887	25	1909	53	89	1896	36	1907	53	98	1911	45	1877, 1903	53
11..	78	1910	25	1882	53	85	1879, 1881	36	1907	49	91	1880	45	1903	46
12..	80	1887, 1896	28	1882, 1900	52	87	1879, 1881	36	1895	51	91	1902	44	1903	47
13..	82	1887	27	1885	55	86	1900	34	1888	52	90	1897	46	1875	44
14..	79	1887	23	1907	56	86	1900	32	1895	54	87	1888	48	1875, 1883, 1909	39
15..	80	1896	27	1893	53	86	1906, 1911	35	1895	51	94	1913	48	1909	46
16..	84	1896	18	1875	66	89	1911	34	1888	55	98	1913	48	1879	50
17..	83	1896	17	1875	66	90	1911, 1906	38	1873	52	96	1887	47	1879	49
18..	83	1896	23	1875	60	92	1911	35	1894	57	91	1872	47	1876	44
19..	77	1906	26	1897	51	91	1911	36	1894	55	98	1872	46	1882	52
20..	74	1899	24	1897	50	86	1887	37	1892	49	92	1872	50	1903	42
21..	83	1902	30	1893	53	83	1876	36	1883	47	91	1894	48	1902	43
22..	78	1913	29	1873	49	87	1912	39	1883	48	93	1894, 1908, 1911	40	1875	53
23..	81	1886	25	1873	56	88	1912	38	1882	50	94	1874, 1911	50	1885	44
24..	81	1895	29	1910	52	84	1896	41	1901	43	93	1901	51	1887	42
25..	80	1906	27	1887	53	94	1911	39	1893	55	93	1895, 1901	50	1883	43
26..	80	1888	31	1875, 1887	49	94	1911	41	1891, 1893	53	91	1913	51	1883	40
27..	82	1888	35	1874	47	94	1911	38	1907	56	96	1913	51	1905	45
28..	83	1888	35	1874	48	88	1895	38	1894	50	93	1874, 1901, 1906	50	1875	43
29..	88	1899	34	1874	54	93	1895	40	1873	53	92	1894, 1906	50	1875	42
30..	84	1894	30	1873	54	91	1895	35	1873	56	99	1913	53	1885, 1902	46
31..	......	......	......	......	......	94	1895	35	1873	59	......	......	......	......	......

TABLE XLIII—*Continued*

DAILY EXTREMES OF TEMPERATURE, 1872–1913

	July					August					September				
	Max.	Year	Min.	Year	Extreme Range	Max.	Year	Min.	Year	Extreme Range	Max.	Year	Min.	Year	Extreme Range
1..	96	1911	53	1885 1892 1904	43	93	1894	57	1875	36	95	1913	52	1872 1885 1895	43
2..	98	1911	56	1882 1904	42	96	1890	54	1907	42	97	1913	50	1888	47
3..	100	1911	53	1892	47	96	1908	48	1894	48	92	1898	52	1877 1893	40
4..	102	1911	56	1872 1882	46	98	1881	53	1880 1894	45	91	1893	48	1902	43
5..	102	1911	52	1872	50	95	1896	53	1884	42	98	1899	52	1896	46
6..	99	1874	52	1873	47	93	1900	52	1875	41	94	1912	47	1885	47
7..	94	1893	54	1883 1894	40	92	1894 1900 1911	57	1875 1902	35	95	1899	49	1898	46
8..	94	1910	53	1883	41	98	1896	55	1904	43	92	1897	46	1883	46
9..	94	1910 1911	50	1895	44	97	1913	52	1884 1888	45	94	1897	48	1883	46
10..	102	1901	52	1873	50	98	1887	51	1882 1884	47	94	1897	48	1883	46
11..	96	1908	53	1873	43	98	1874	55	1882 1902 1903	43	92	1895 1908	47	1878	45
12..	96	1887	56	1900	40	92	1905	57	1902	35	87	1874	48	1902	39
13..	95	1880	56	1883 1888 1897	39	86	1876 1912	54	1888	32	89	1909	39	1890	50
14..	93	1874 1896	58	1882 1883 1884 1888	35	93	1895	56	1885	37	95	1893	42	1873	53
15..	96	1887	54	1889	42	86	1904	55	1885	31	91	1897	42	1873	49
16..	100	1887	55	1889	45	94	1908	56	1883	38	89	1891 1899	46	1900	43
17..	100	1887	59	1886	41	91	1874	52	1879	39	90	1891	41	1900	49
18..	95	1905	54	1873 1883	41	93	1880 1900	54	1897	39	90	1908	40	1889 1901 1903	50
19..	95	1913	50	1873	45	93	1874	58	1875	35	91	1895	41	1873	50
20..	97	1901	56	1873	41	94	1874	56	1890 1897	38	91	1895	42	1896	49
21..	103	1901	57	1877 1880 1882 1889 1900 1902	46	93	1872	53	1875	40	90	1895	39	1889	51
22..	92	1906	56	1872	36	92	1906	51	1890	41	90	1895	38	1913	52
23..	92	1892	57	1896	35	93	1898	51	1888	42	88	1892	38	1887	50
24..	97	1910	56	1905	41	92	1873 1903	49	1887	43	91	1891	40	1879 1887	51
25..	98	1874	56	1890	42	90	1912	50	1887	40	89	1900	39	1879 1893 1907	50
26..	95	1910	58	1890	37	89	1881 1888 1913	47	1887	42	86	1908	39	1893 1912	47
27..	95	1901	57	1872	38	89	1877	54	1876 1896	35	87	1891	35	1889	52
28..	94	1886	56	1891	38	90	1897	49	1891	41	83	1904 1905	39	1888	44
29..	92	1896 1909	56	1883	36	88	1889 1905	53	1891	35	87	1898	36	1888 1908	51
30..	92	1888 1890	58	1883 1889 1895	34	90	1881 1898	49	1872	41	86	1877	32	1899	54
31..	94	1888	54	1895	40	95	1912	47	1872	48	......	......	......	......	......

TABLE XLIII—*Continued*

DAILY EXTREMES OF TEMPERATURE, 1872–1913

	October					November					December				
	Max.	Year	Min.	Year	Extreme Range	Max.	Year	Min.	Year	Extreme Range	Max.	Year	Min.	Year	Extreme Range
1..	85	1901	32	1886	53	75	1888	21	1879	54	57	1901	− 6	1893	63
2..	86	1891	37	1886	49	69	1886, 1896	23	1911	46	57	1873	− 1	1893	58
3..	84	1891	32	1888	52	67	1887	20	1901	47	60	1873	0	1895	60
4..	86	1897	36	1901	50	67	1895, 1898	16	1901	51	57	1913	0	1893	57
5..	86	1900	34	1876	52	68	1874	24	1901	44	62	1879	6	1895	56
6..	84	1879, 1912	38	1885	46	67	1887	22	1877, 1910	45	56	1879, 1883	0	1885	56
7..	82	1887	34	1876	48	72	1874	25	1886	47	57	1883, 1892	− 6	1882	63
8..	83	1905	33	1876	50	69	1879	17	1892	52	59	1889	− 7	1882	66
9..	82	1879	33	1895	49	67	1910	23	1896	44	62	1879	−14	1876	76
10..	83	1913	30	1906	53	66	1909	22	1913	44	62	1879	0	1876	62
11..	81	1893	27	1906	54	74	1911	16	1894	58	60	1886	8	1892	52
12..	79	1886	30	1887	49	70	1902	13	1911	57	61	1877	3	1893, 1903, 1912	58
13..	83	1899	29	1909	54	70	1909	12	1911	58	59	1881	−13	1903	72
14..	86	1897	27	1872	59	65	1902, 1909	14	1900	51	57	1891	− 9	1901	66
15..	87	1897	28	1876	59	62	1896	14	1883, 1900	48	59	1877	−12	1901	71
16..	83	1910	32	1876	51	70	1896	10	1883	60	58	1877	− 8	1876	66
17..	84	1910	32	1880	52	64	1881	8	1880, 1891	56	55	1877	− 1	1875, 1884	56
18..	78	1910	28	1880	50	65	1896, 1904	8	1880	57	62	1877	− 9	1884	71
19..	81	1910	30	1880	51	67	1913	10	1894	57	64	1877	−11	1884	75
20..	75	1872	24	1895	51	68	1913	8	1873	60	67	1877	− 8	1901	75
21..	82	1908	27	1913	55	72	1913	1	1880	71	55	1875, 1894	−12	1872	67
22..	79	1901	26	1887	53	69	1913	4	1880	65	57	1875	−21	1872	78
23..	82	1899, 1901	25	1895	57	61	1886	10	1898	51	57	1877	−18	1872	75
24..	76	1899, 1902	23	1887	53	59	1908	4	1893	55	64	1889	−23	1872	87
25..	74	1899	14	1887	60	65	1908	7	1893	58	56	1895	− 2	1892, 1903	58
26..	74	1900	22	1887	52	63	1896	2	1898	61	53	1888	−10	1892, 1903	63
27..	70	1896	28	1878	42	63	1909	2	1887	61	58	1907	−10	1886	68
28..	75	1874, 1896	24	1895	51	69	1905	0	1872, 1887	69	50	1889	−12	1880	62
29..	78	1901	24	1873, 1895	54	59	1913	− 2	1872	61	61	1889	−15	1880	76
30..	75	1901	23	1887	52	58	1908, 1911	0	1874	58	61	1884	− 7	1909	68
31..	76	1888	23	1873	53	......	......	......	......	......	68	1875	− 1	1880, 1899	69

Table XLIII shows the highest and the lowest temperatures recorded on each day of the year from 1872 to 1913, with year of occurrence and the extreme range for the day.

SUMMARY OF TABLE XLIII

ABSOLUTE EXTREMES OF TEMPERATURE

1872–1913	Absolute Maximum	Year	Day	Absolute Minimum	Year	Day	Absolute Range
January....	65°	1876 1909	1 23	−20°	1875 1897	9 25	85°
February...	63°	1876 1880	10 26	−21°	1899	9	84°
March......	81°	1910	27	−12°	1873	4	93°
April.......	88°	1899	29	17°	1875 1879 1881	17 3 1	71°
May	94°	1895 1911	31 25*	27°	1875	2	67°
June	99°	1913	30	40°	1875 1894	22 6	58°
July........	103°	1901	21	50°	1873 1895	19 9	53°
August	98°	1874 1881 1887 1896	11 4 10 8	47°	1872 1887	31 26	51°
September ..	98°	1899	5	32°	1899	30	66°
October.....	87°	1897	15	14°	1887	25	73°
November ..	75°	1888	1	− 2°	1872	29	77°
December...	68°	1875	31	−23°	1872	24	91°
Year.......	103°	1901	July 21	−23°	1872	Dec. 24	126°

* Also on the 26th and 27th.

about a month before the average date for the absolute winter minimum (Table XLIV). Zero or lower has been recorded in some year or other on every day of January and February, and on every day of December except the 5th, 11th, and 12th. The greatest difference between the extremes of temperature for any one day throughout the year, that is, the greatest absolute range, is 87° on December 24, from 64° in 1889 to −23° in 1872.

INTERVAL BETWEEN OCCURRENCE OF LOWEST AND HIGHEST TEMPERATURES, WINTER TO SUMMER

The lowest mean temperature of the year occurs on February 1, and the highest mean on July 16, 165 days later (p. 26), but it is seldom that the extreme temperatures of winter and summer are actually experienced on those dates. In fact, as will be seen in Table XLIV and Fig. 14, the absolute minimum of the winter season has never occurred on February 1, and the absolute maximum of summer has fallen on July 16 only three times since the official records began. The winter minimum usually accompanies the passage of a more or less severe cold wave, and the summer maximum ordinarily attends a period of pronounced heat in the interior portions of the

country. Both occurrences are the result of conditions much more complicated than the simple swing of the sun from tropic to tropic, and are far from being coincident with the time of arrival of that

TABLE XLIV

TIME OF OCCURRENCE OF ANNUAL MINIMUM AND MAXIMUM TEMPERATURES, WITH INTERVAL, 1871–1913

(These values, not including 1910–13, are shown graphically in Fig. 14)

	Minimum	Date of Minimum				Date of Maximum				Maximum	Summer	Interval in Days
		Dec.	Jan.	Feb.	Mar.	June	July	Aug.	Sept.			
1871–72	−12		29			19				98	1872	142
1872–73	−23	24					16			93	1873	204
1873–74	− 6		15				6			99	1874	172
1874–75	−20		9			11				89	1875	153
1875–76	− 3			2			7			93	1876	155
1876–77	−14	9					8			91	1877	211
1877–78	− 1		7				16			97	1878	190
1878–79	−18		3				15			93	1879	193
1879–80	− 2	26					13			95	1880	200
1880–81	−15	29						4		98	1881	218
1881–82	1		17				27			90	1882	191
1882–83	−17		22				3			91	1883	162
1883–84	−18		5					19		91	1884	227
1884–85	−14			11			20			94	1885	159
1885–86	−14		23				6			94	1886	164
1886–87	−15		3				16			100	1887	194
1887–88	−18			9			31			94	1888	173
1888–89	−11			23			9			90	1889	136
1889–90	− 5		22					2		96	1890	192
1890–91	− 8			4				9		96	1891	186
1891–92	− 5		9				25			94	1892	197
1892–93	−16		15					10*		95	1893	207
1893–94	− 9		25				24			96	1894	180
1894–95	−15			8		3				95	1895	115
1895–96	− 9		4*					8		98	1896	217
1896–97	−20		25				3			95	1897	159
1897–98	− 8			3			19			94	1898	166
1898–99	−21			9					5	98	1899	208
1899–1900	− 9			24*				5		94	1900	163
1900–1901	− 5		1				21			103	1901	201
1901–2	−12	15				12				91	1902	179
1902–3	−11			17			1*			92	1903	134
1903–4	−15		25				17			94	1904	174
1904–5	−18			13			18			95	1905	155
1905–6	6			2		28				93	1906	146
1906–7	− 3		26						1	92	1907	218
1907–8	− 2			2			11*			96	1908	160
1908–9	−10		6					8		93	1909	214
1909–10	− 7	30					24			97	1910	206
1910–11†	0		5				5			102	1911	181
1911–12†	−16		7					31		95	1912	236
1912–13†	− 4				2		29*			99	1913	148
No. of occurrences	......	6	22	13	1	5	26	9	2	......	......	......
Mean	......	......	20	......	......	......	19	......	......	......	......	180

* On other dates also; latest date of minimum and earliest date of maximum given in table.

† Not included in means.

luminary at either end of his journey. The lowest temperature of the winter season has occurred as early as December 9 and as late as March 2; the highest temperature of summer has occurred as early as June 3, and in one instance was delayed until September 5.

The average times of these extremes are January 20 and July 19, respectively, and the interval between extends over 180 days. There is, however, a considerable range in the interval between the occurrence of the lowest and highest temperatures, the longest on record

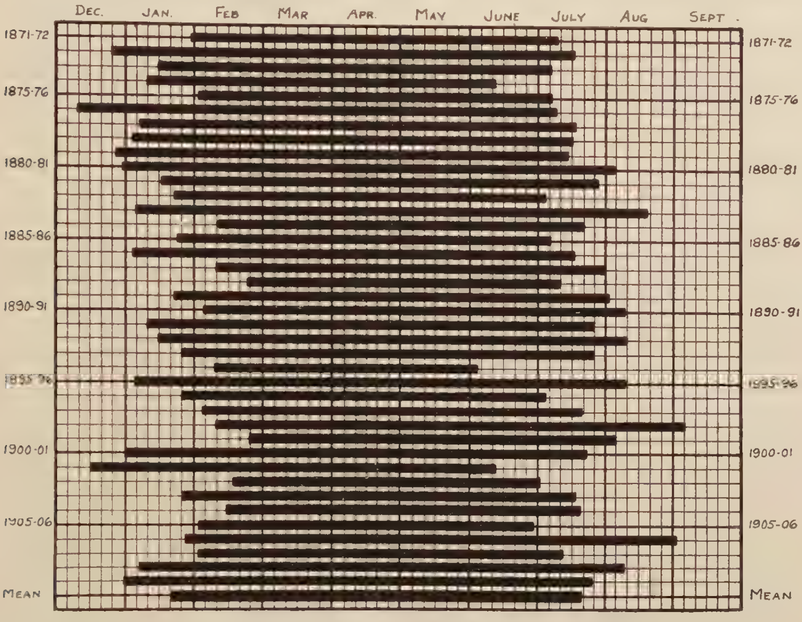


Fig. 14.—Interval between time of occurrence of lowest and highest temperatures.

Fig. 14 shows the time of occurrence of the lowest temperature each winter and the highest temperature of each succeeding summer from 1871 to 1910; also the length of the intervening period. The lowest line marked "mean" shows the average time of occurrence and the average length of the intervening period (see Table XLIV).

being 236 days in 1912, from January 7 to August 31, while the shortest, 115 days in 1895, from February 8 to June 3, was only a little less than half that time.

OCCURRENCE OF FROST

The length of time each year during which the temperature is sufficiently high to permit the growth of vegetation has been established in a previous topic (p. 86) as 221 days, but attention was there called to the fact that this period does not represent the actual growing season for annuals or plants susceptible to damage by low temperatures. It now remains to inquire into the occurrence of frosts and

frost temperatures, and to determine the limits within which tender plants may reasonably be regarded as safe. According to Weather Bureau usage, three kinds of frost are distinguished: *light frost*, which has no destructive effect, except on the tenderest plants and vines in exposed places; *heavy frost*, which is accompanied by a considerable deposit, but is yet not severe enough to affect the hardier annuals; and *killing frost*, which destroys all susceptible growth, even if there is no actual deposit of hoar frost. This last condition is usually attended by the formation of ice on shallow puddles and pools. A dry freeze unattended by the formation of hoar frost is, in fact, often the most damaging, because it is the result of low temperatures throughout a considerable portion of the night; whereas a lower reading may occur on some other night but the damage yet be much less because the temperature falls rapidly to its minimum and immediately rises to a point above the danger mark.

From the above explanations it will be plain that the recording of the various classes of frost must depend largely upon the judgment of the observer as to the damage sustained by the different kinds of vegetation. Obviously, in a large city this is a very difficult task, as the extent of vegetation is limited, and much of that existing is to some extent at least under artificial protection. For this reason, while the actual occurrences of frosts are recorded as far as they can be observed, certain temperatures, called *frost temperatures*, are noted as the limits above which frost is not likely to occur.

1. *Minimum temperature of 40°, or light frost.*—Ordinarily, during the spring and fall light frost will occur in portions of the city when the air temperature at the Weather Bureau office has fallen to 40°, if the sky is clear enough to promote rapid radiation at night and the wind not of sufficient force to keep the lower strata of the atmosphere well mixed. In fact, there are certain localities in the outskirts where the relatively lower surface of the ground gathers the colder, heavier air as in a cup, and in these sections light frost often occurs when the official thermometers record a minimum temperature considerably higher than 40° (p. 13). Even in the section where frost has formed the temperature of the air does not necessarily fall to the freezing point, but it is the surface of the object on which the frost forms that has cooled to 32°. The air itself is both a poor absorber and a poor radiator of heat, and most objects, such as leaves of plants, edges of boards, and loamy soils, become much cooler under a clear sky at night than does the air, because they are

more active in radiating the heat accumulated during the day. Thus the temperature of the surface of such objects may descend below the freezing point, and frost is therefore likely even though the temperature of the air is considerably above 32°.

Table XLV and Fig. 15 show the dates of the last occurrence in spring and the first in autumn of the frost temperature of 40°. The interval between these dates is also shown, while the table indicates

TABLE XLV

LAST AND FIRST OCCURRENCE OF A MINIMUM TEMPERATURE OF 40° (LIGHT FROST TEMPERATURE), 1871–1912

(See Fig. 15)

Year	Last in Spring			First in Autumn			Interval in Days	Departure from Average
	April	May	June	Sept.	Oct.	Nov.		
1871	....	4	....	28	....	....	146	+ 2
1872	....	4	....	27	....	....	145	+ 1
1873	....	31	....	....	6	....	127	−17
1874	....	18	....	....	12	....	146	+ 1
1875	....	....	22	21	....	....	90	−54
1876	....	6	....	29	....	....	145	+ 1
1877	....	10	....	....	5	....	147	+ 3
1878	....	13	....	....	18	....	157	+13
1879	....	6	....	24	....	....	140	− 4
1880	....	1	....	30	....	....	151	+ 7
1881	....	3	....	....	....	2	182	+38
1882	....	23	....	....	24	....	153	+ 9
1883	....	23	....	....	3	....	132	−12
1884	....	7	....	....	22	....	167	+23
1885	....	19	....	....	4	....	137	− 7
1886	....	7	....	....	1	....	146	+ 2
1887	27	....	....	23	....	....	148	+ 4
1888	....	19	....	28	....	....	131	−13
1889	....	31	....	18	....	....	109	−35
1890	....	17	....	13	....	....	118	−26
1891	....	16	....	....	5	....	141	+ 7
1892	....	20	....	....	6	....	138	− 6
1893	....	25	....	25	....	....	122	−22
1894	....	....	6	....	4	....	119	−25
1895	....	21	....	30	....	....	131	−13
1896	10	....	....	23	....	....	165	+21
1897	....	25	....	....	29	....	156	+12
1898	....	6	....	....	13	....	159	+15
1899	22	....	....	29	....	....	159	+15
1900	....	20	....	....	....	2	165	+21
1901	23	....	....	18	....	....	147	+ 3
1902	....	27	....	....	13	....	138	− 6
1903	....	3	....	18	....	....	137	− 7
1904	....	16	....	....	22	....	158	+14
1905	....	9	....	....	11	....	154	+10
1906	....	9	....	....	9	....	152	+ 8
1907	....	27	....	25	....	....	120	−24
1908	....	6	....	28	....	....	144	0
1909	....	3	....	....	11	....	160	+16
1910	....	4	....	....	27	....	175	+31
1911*	....	3	....	....	22	....	171	+27
1912*	....	13	....	....	26	....	135	− 9
Average date:								
1871–80	....	15	....	....	2	....	139	±10.3
1881–90	....	15	....	....	5	....	142	±16.9
1891–1900	....	14	....	....	8	....	146	±15.7
1901–10	....	10	....	....	6	....	148	±11.9
1871–1910	....	14	....	....	5	....	144	±13.9

* Not included in means.

for each season the excess length or the deficiency as based upon the average period of frost-free temperatures given at the bottom. The last frost temperature of spring has occurred in May 36 times during the 42 years from 1871 to 1912; in April, 4 times, once as early as the 10th; and in June only twice, the latest occurrence being June 22 in 1875. The average date of the last occurrence in spring is May 14. The average date of the first occurrence of the frost temperature in autumn is October 5. It will be seen from the table that there have been nearly as many occurrences in September as in October, but this does not indicate any greater irregularity in the autumn, because

the equated dates fall 9 days earlier in the month than is the case in the spring. Frost temperatures in the latter half of the year have been noted as early as September 13, and in two instances have been delayed until November 2. The average interval between the equated dates in spring and fall is 144 days, and this may be regarded as the length of time through which freedom from injury by low temperatures may reasonably be expected for the most susceptible plants common to the locality. In the 42 years of record, 25 seasons

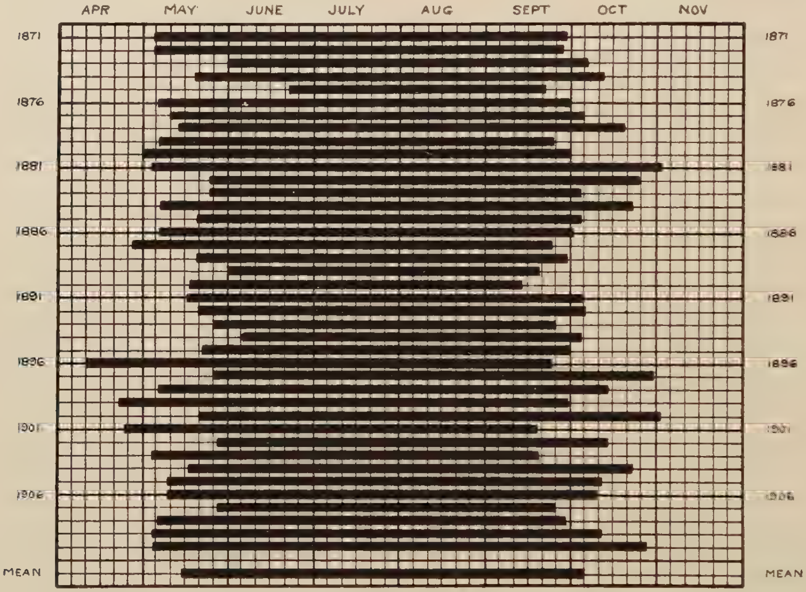


FIG. 15.—Interval between last and first occurrence of a minimum temperature of 40° (light frost).

Fig. 15 shows the time of last occurrence of a minimum temperature of 40° in spring and that of the first occurrence in fall, together with the length of the intervening period. The lowest line marked "mean" shows the date of the average occurrence and the average length of the intervening period (see Table XLV).

have been longer than the average and only 16 have been shorter, but in the latter cases the departures have as a rule been the most pronounced. The season of 1908 was exactly of the average length, but with opening and closing earlier than the equated dates by about 8 days; the longest period was in 1881, from May 3 to October 2, 182 days; while in 1875, the year of lowest mean temperature, only 90 days intervened between the first and last occurrences of frost temperatures on June 22 and September 21, respectively.

2. *Killing frosts.*—No special data have been prepared on the occurrence of heavy frosts because of the personal error possible in judging the different degrees of intensity laid down for light and heavy deposits; and, indeed, both light and heavy frosts may occur

TABLE XLVI

LAST AND FIRST OCCURRENCE OF KILLING FROSTS, 1871–1912

Year	Last in Spring	Min. Temp.	First in Autumn	Min. Temp.	Interval in Days
1871	Mar. 23	32°	Oct. 28	26°	218
1872	Apr. 16	32°	Oct. 10	31°	176
1873	Apr. 30	30°	Oct. 23	28°	175
1874	Apr. 24	30°	Nov. 1	29°	190
1875	May 2	27°	Oct. 2	38°	152
1876	Apr. 2*	32°	Oct. 4	38°	184
1877	Apr. 5*	32°	Oct. 5	37°	182
1878	May 13	38°	Oct. 19	34°	158
1879	Apr. 4*	25°	Oct. 24	34°	202
1880	Apr. 12*	31°	Oct. 18	28°	188
1881	Apr. 7*	26°	Nov. 3	36°	209
1882	May 16	37°	Nov. 13	25°	180
1883	Apr. 24	32°	Nov. 1	31°	190
1884	Apr. 3*	32°	Oct. 23	28°	202
1885	May 10	38°	Oct. 6	38°	148
1886	Apr. 8*	32°	Oct. 1	32°	175
1887	Apr. 25	27°	Oct. 12	30°	169
1888	May 16	34°	Oct. 3	32°	139
1889	Apr. 6*	29°	Sept. 27	35°	173
1890	Apr. 14*	28°	Oct. 27	34°	195
1891	Apr. 8*	31°	Oct. 22	33°	196
1892	Apr. 24	32°	Oct. 6	40°	164
1893	Apr. 22	31°	Oct. 16	38°	176
1894	Apr. 9*	31°	Oct. 6	39°	179
1895	May 14	32°	Sept. 30	36°	138
1896	Apr. 9*	32°	Oct. 18	34°	191
1897	May 1	33°	Nov. 3	36°	185
1898	Apr. 6*	27°	Oct. 15	40°	191
1899	Apr. 5	29°	Sept. 30	32°	177
1900	Apr. 13*	32°	Nov. 6	38°	206
1901	Apr. 19	34°	Oct. 17	33°	180
1902	Apr. 8*	26°	Nov. 23	31°	228
1903	Apr. 5*	30°	Oct. 27	33°	204
1904	Apr. 21	31°	Oct. 28	34°	189
1905	Apr. 7*	31°	Oct. 21	35°	196
1906	Mar. 31*	32°	Oct. 10	30°	192
1907	May 4	35°	Oct. 14	39°	162
1908	Apr. 3*	26°	Oct. 12	41°	191
1909	May 2	33°	Oct. 14	29°	164
1910	Apr. 24	29°	Oct. 29	27°	187
1911†	Apr. 7	32°	Oct. 24	36°	199
1912†	Apr. 18	32°	Oct. 24	39°	188
Average	Apr. 18	....	Oct. 18	....	182
Earliest	Mar. 23, 1871	....	Sept. 27, 1889	....	Longest, 228
Latest	May 16, 1888	....	Nov. 23, 1900	....	Shortest, 138

* Not customary to record frosts until April 15, dates given being the last occurrence of freezing temperature.

† Not included in averages.

at the same time in localities in close proximity to each other. In the case of a killing frost, however, the effects are practically in all cases easily discerned, especially in the autumn, when vegetation is in full development. Table XLVI will therefore be valuable in establishing the average and extreme limits of the growing season, so far as the

ordinary annual and deciduous plants and shrubs are concerned. The accompanying minimum temperatures are given in the table, which has reference to the actual occurrence of killing frost, without regard to the temperature at the time, and in this respect it differs from the preceding table and the one following, these being concerned only with the first and last occurrences of certain temperatures, 40° and the freezing point, respectively. The average interval between the last killing frost in the spring and the first in the autumn is 182 days, and extends from April 18 to October 18, but the season has ranged from 228 days in 1902 to only 138 days in 1895. It has not been customary to record frosts in this latitude prior to April 15 of each year, so that in the table all dates before April 15 are those of the last occurrence of a temperature of 32°. In 1871 this date fell as early as March 23, while in 1888 a killing frost occurred as late as May 16. In 1889 killing frost occurred on September 27, the earliest autumn record for this phenomenon, while in 1902 the season was extended until November 23. It will be noted that the minimum temperatures, counting only the actual occurrences of killing frost as recorded in the table, range from several degrees below the freezing point to nearly 10° above. In 1908 killing frost occurred with a minimum temperature at the Weather Bureau office of 41°, and a number of instances where the minimum was from 35° to 40° may be picked out. The explanation is simply that of the varying conditions of radiation due to differences in cloudiness and character of exposure, and the effect of wind movement, as has been brought out previously (pp. 13, 108).

3. *Minimum temperature of 32°, or freezing point.*—As frosts do not occur in cloudy weather or on nights in which the wind movement is brisk, damage to vegetation at such times is wrought by the actual occurrence of freezing temperatures, and under the conditions outlined temperatures in the various portions of the city do not differ appreciably from those recorded at the Weather Bureau office. In England the expression "degrees of frost" has reference to the number of degrees the temperature falls below the freezing point. We do not make use of this term in the United States, and it would be difficult to prepare data relative to such a term, if unlimited. It will, however, be helpful in securing a knowledge of the temperature conditions in Chicago to note the interval between the first and last occurrence of the freezing point, 32°, each year, and these data are presented in Table XLVII and Fig. 16, in substantially the same

manner as was used in the treatment of the occurrence of the frost temperature (Table XLV, Fig. 15). The average interval is 193 days in length, and extends from April 16 to October 27. The longest interval on record was 228 days, from April 8 to November 23, 1902, November of that year being exceptionally warm; while the shortest was 154 days, from May 1 to October 3, 1888. In 1871, 32° was not reached later than March 23, and in 1895 it occurred as late as May 14. In the fall the earliest recorded date is September 30, 1899; and the latest, November 23, 1902, mentioned above as the expiration of the longest interval of temperatures above freezing.

TABLE XLVII

Last and First Occurrence of a Temperature of 32° or Freezing Point, 1871–1912

(See Fig. 16)

Year	Last in Spring			First in Autumn			Interval in Days	Departure from Average
	Mar.	April	May	Sept.	Oct.	Nov.		
1871	23	....	....	....	27	....	217	+24°
1872	....	16	....	....	10	....	176	−17°
1873	....	30	....	....	23	....	175	−18°
1874	....	24	....	....	31	....	189	− 4°
1875	....	....	2	....	30	....	180	−13°
1876	....	30	....	....	15	....	167	−26°
1877	....	30	....	....	....	3	186	− 7°
1878	25	....	....	....	27	....	215	+22°
1879	....	4	....	....	31	....	209	+16°
1880	....	12	....	....	17	....	187	− 6°
1881	....	14	....	....	....	14	213	+20°
1882	....	12	....	....	....	12	213	+20°
1883	....	24	....	....	....	1	190	− 3°
1884	....	3	....	....	23	....	202	+ 9°
1885	....	13	....	....	....	13	213	+20°
1886	....	8	....	....	1	....	175	−18°
1887	....	26	....	....	12	....	168	−25°
1888	....	....	1	....	3	....	154	−39°
1889	....	6	....	....	....	4	211	+18°
1890	....	14	....	....	30	....	198	+ 5°
1891	....	8	....	....	....	1	206	+13°
1892	....	24	....	....	30	....	188	− 5°
1893	....	22	....	....	28	....	188	− 5°
1894	....	9	....	....	14	....	187	− 6°
1895	....	....	14	....	20	....	158	−35°
1896	....	9	....	....	19	....	192	− 1°
1897	....	20	....	....	....	6	199	+ 6°
1898	....	6	....	....	23	....	199	+ 6°
1899	....	8	....	30	....	....	174	−19°
1900	....	13	....	....	....	8	208	+15°
1901	....	18	....	....	....	3	198	+ 5°
1902	....	8	....	....	....	23	228	+35°
1903	....	5	....	....	....	6	214	+21°
1904	....	21	....	....	....	11	203	+10°
1905	....	16	....	....	28	....	194	+ 1°
1906	31	....	....	....	10	....	192	− 1°
1907	....	26	....	....	....	10	197	+ 4°
1908	....	3	....	....	....	5	215	+22°
1909	....	....	1	....	12	....	163	−30°
1910	....	24	....	....	28	....	186	− 7°
1911*	....	7	....	....	27	....	202	+ 9°
1912*	....	18	....	....	....	1	196	+ 3°
Average date:								
1871–80	....	16	....	....	24	....	190	......
1881–90	....	15	....	....	27	....	194	......
1891–1900	....	16	....	....	24	....	190	......
1901–10	....	15	....	....	....	1	199	......
1871–1910	....	16	....	....	27	....	193	......

* Not included in means.

Both this record of the first and last occurrence of freezing temperature, and that in the previous paragraph on killing frosts, bear out all that has previously been stated regarding the influence of Lake Michigan in tending to maintain moderate temperatures near its shore. The average growing season at LaGrange, whose temperatures have been compared with those of Chicago (p. 46), as determined from its record of killing frosts, is an interval of 163 days,

and extends from May 1 to October 11; whereas, as shown in Tables XLVI and XLVII, in the city the period of freedom from killing frosts is 19 days longer, extending from April 18 to October 18. The average interval between the occurrence of last and first actual temperature of 32° in Chicago is 11 days longer than its season between killing

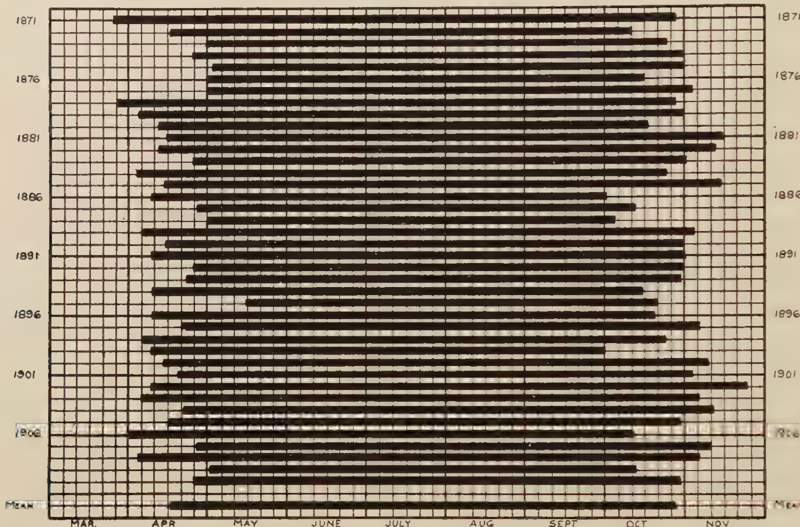


FIG. 16.—Interval between last and first occurrence of a temperature of 32°, 1871–1910.

Fig. 16 shows the time of occurrence of the last freezing temperature in spring and the first in autumn; also the length of the intervening period. The lowest line marked "mean" shows the date of the average occurrence and the average length of the intervening period (see Table XLVII).

frosts, but is fully 30 days longer than the record for LaGrange. Similarly, none of the stations in northern Illinois appearing in Table XXI (p. 54) has as long a season free from killing frosts as does Chicago (see *Bulletin W*, *Summary of Climatological Data for the United States*, sec. 64, p. 6).

RANGE IN TEMPERATURE

The difference between the maximum and minimum temperatures of any place is called the range in temperature for that point, and may be either absolute—that is, calculated for individual years, months, or days—or mean—that is, based upon the average maximum and minimum values. The term indicates the amount of temperature

change experienced in a locality, and it is therefore an important factor in the discussion of climate and weather. In Table XLVIII the absolute annual range for Chicago is given in the last column for the entire period of official record, and the mean for the year shows an average annual fluctuation through 106°3. As the highest tempera-

TABLE XLVIII

Absolute Monthly and Annual Ranges in Temperature, 1871–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Greatest	Absolute Annual
1871........	52	50	35	44	46	31	33	36	47	49	52	53	53	100
1872........	57	54	37	54	45	47	45	37	56	53	61	69	69	121
1873........	67	65	72	58	52	48	43	39	47	52	51	47	72	111
1874........	66	47	47	45	51	49	39	40	45	48	72	51	72	105
1875........	64	58	64	55	52	49	32	34	47	43	57	69	69	109
1876........	61	66	59	38	52	41	36	38	41	45	50	59	66	107
1877........	60	37	60	51	53	42	34	34	42	45	44	45	60	95
1878........	50	38	43	39	40	35	38	34	44	52	26	55	55	106
1879........	67	57	55	63	48	44	33	39	44	56	53	64	67	111
1880........	42	51	41	53	50	39	38	40	45	50	62	65	65	110
1881........	54	43	37	60	50	43	36	40	45	36	50	46	60	111
1882........	57	52	41	41	42	46	35	36	45	37	51	52	57	97
1883........	57	66	52	50	44	36	40	35	42	40	52	57	66	108
1884........	67	56	60	46	38	39	35	40	38	55	59	72	72	109
1885........	63	61	54	49	46	46	41	30	34	33	38	52	63	108
1886........	62	62	55	58	42	38	39	39	44	47	53	70	70	108
1887........	67	65	59	63	44	48	39	51	54	68	68	58	68	115
1888........	61	65	65	53	49	47	38	40	52	44	55	38	65	112
1889........	55	59	48	44	52	44	36	34	49	44	45	49	59	101
1890........	67	56	56	47	52	40	37	45	49	45	40	45	67	101
1891........	44	66	50	52	46	44	32	47	43	53	57	48	66	104
1892........	60	47	48	55	39	48	41	43	42	48	46	67	67	104
1893........	62	55	60	57	46	37	34	41	56	55	63	64	64	111
1894........	69	52	65	53	53	53	42	47	46	44	50	58	69	105
1895........	60	76	71	52	62	45	42	35	56	47	59	56	76	110
1896........	59	67	52	66	43	39	37	44	48	46	64	49	67	107
1897........	77	50	41	54	48	49	39	36	52	49	59	59	77	115
1898........	49	68	47	57	42	38	35	34	43	45	65	46	68	102
1899........	61	70	61	70	41	41	31	28	66	48	33	59	70	119
1900........	64	71	56	51	50	40	37	30	49	45	49	51	71	103
1901........	59	36	67	53	46	54	47	32	47	52	50	69	69	115
1902........	58	55	62	60	50	43	36	31	39	41	44	51	62	99
1903........	57	60	61	50	52	46	33	37	46	50	51	53	61	105
1904........	54	59	52	56	49	40	41	35	40	44	48	52	59	109
1905........	53	65	60	47	46	42	39	30	34	54	55	45	65	113
1906........	52	48	46	46	54	42	33	36	34	48	39	46	54	87
1907........	62	55	57	47	49	44	35	38	53	46	31	39	62	95
1908........	49	52	50	52	53	46	36	38	56	48	41	43	56	98
1909........	75	45	41	49	54	39	37	34	42	47	43	62	75	103
1910........	51	57	55	60	40	48	35	36	34	57	47	36	60	103
1911*........	54	50	60	43	61	43	49	33	35	47	62	55	62	102
1912*........	54	57	50	44	49	38	35	40	55	46	45	54	57	111
1913*........	55	64	69	48	47	55	40	37	59	56	52	39	69	103
Means.......	59.3	56.6	53.6	52.4	47.8	43.2	37.2	37.3	45.9	47.7	50.8	54.2	65.3	106.3
Greatest monthly range	77	76	72	70	62	55	49	51	66	68	72	72	77	121
Least monthly range......	42	36	35	38	38	31	31	28	34	33	26	36	26	87

* Not included in means.

Table XLVIII shows the absolute monthly range of temperature, that is, the difference between the absolute monthly maximum and the absolute monthly minimum; also the absolute monthly range for each year, and the absolute annual range, the latter being the difference between the lowest minimum and highest maximum during each year (see Tables XXV and XXVI).

SUMMARY OF TABLE XLVIII

EXTREME MONTHLY RANGES IN TEMPERATURE, 1871–1913

(See Fig. 18)

Month	Year	Range	Maximum	Minimum
January	1897	77	57	−20
February	1895	76	61	−15
March	1873	72	60	−12
April	1899	70	88	18
May	1895	62	94	32
June	1913	55	99	44
July	1911	49	102	53
August	1887	51	98	47
September	1899	66	98	32
October	1887	68	82	14
November	1874	72	72	0
December	1884	72	61	−11

ture on record for Chicago is 103° and the lowest −23° (Table XLIII), the recorded absolute extreme for the city is 126°, but this extreme range for the whole period of observations has never been experienced in any one year. In 1872, however, the range reached 121°, and there are a number of years in which it exceeded 110. In only 6 years of the record has the range been less than 100°, the least being a fluctuation through only 87° in 1906, from a maximum of 93° to a minimum of 6°.

Fig. 17 shows graphically the annual range of temperature at Chicago, together with seven other cities of the United States, roughly in meridian and parallel arrangement, for a period of 35 years ending with 1905, and serves to illustrate the variation in the annual oscillation of temperature in the different sections of the country represented. The average annual range at Chicago for this period was 108°, slightly higher than that shown in Table XLVIII, as the generally higher minimum temperatures of the last five years of record have reduced the mean range by nearly 2°, but this does not affect the comparison with the other cities shown, the records being all for the same period. From the upper portion of the figure it will be seen that the annual range in temperature steadily decreases from north to south, that Duluth experiences annually fluctuations nearly equal to the greatest yearly range in the record of Chicago, that at Memphis the average range of the year is just that of Chicago's lowest record, while at New Orleans the amplitude is less than Chicago's average by 38°. The extreme cold of winter in the northern sections and the high summer temperatures produced by long hours of sunshine falling upon the great land expanse of the level plains states results in a far greater annual range than is found in any region to the southward. In the

lower portion of the figure the effect of the westerly winds blowing from the Pacific Ocean may be seen in the very small average yearly range for San Francisco, which is less than half that for Chicago. At New York, while proximity to the Atlantic Ocean has reduced the annual range considerably, the effect is not nearly so great as is that of the Pacific along the western coast, because the prevailing winds at New York blow from the landward side; yet the ocean influence is sufficient to bring the average yearly range 14° under the

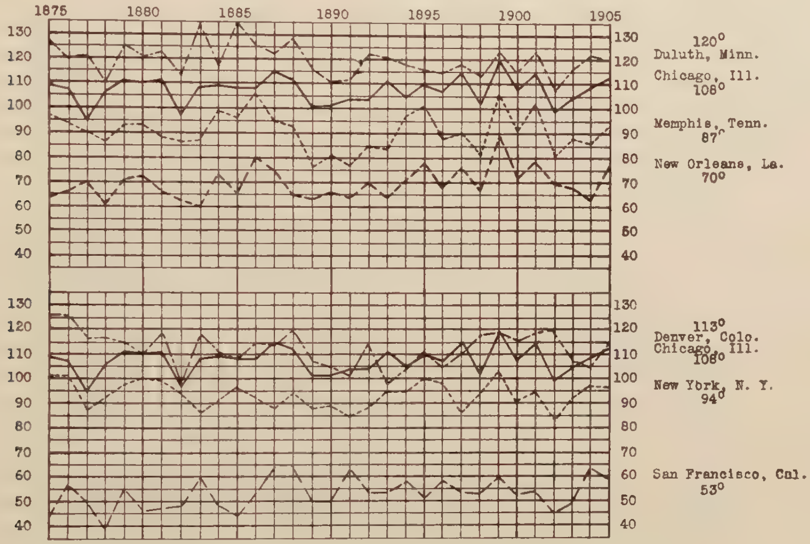


FIG. 17.—Annual range in temperature, 1875–1905.

Fig. 17 shows the annual range in temperature of certain selected cities. The upper graph shows the range for cities passing from north to south from Duluth to New Orleans and including Chicago and Memphis, while the lower graph shows the range for cities from east to west and including New York, Chicago, Denver, and San Francisco.

range for Chicago. Denver experiences annually fluctuations that average 5° greater than those in this city, and the greater range is due to the higher altitude and the rarer atmosphere in the case of the former, and the moderating influence of Lake Michigan in the case of the latter. While the annual range at Chicago is considerable, it is not as great, as a rule, as that observed on the Great Plains and in the eastern foothills of the Rockies; and it is, in fact, of such an extent as rather to stimulate the energies and activities of its people than otherwise.

Table XLVIII also contains the absolute range in temperature for each month since 1871, that is, the difference between the absolute maximum and the absolute minimum for the month. Just as the daily changes in mean temperature are greater in winter than in summer (p. 30), so are the mean monthly ranges in temperature, the average range for January being 59°.3 and that for July 37°.2. The greatest range in any one month was 77°, in January, 1897; and the least, 26°, curiously enough occurred in November, 1878, and is 2°

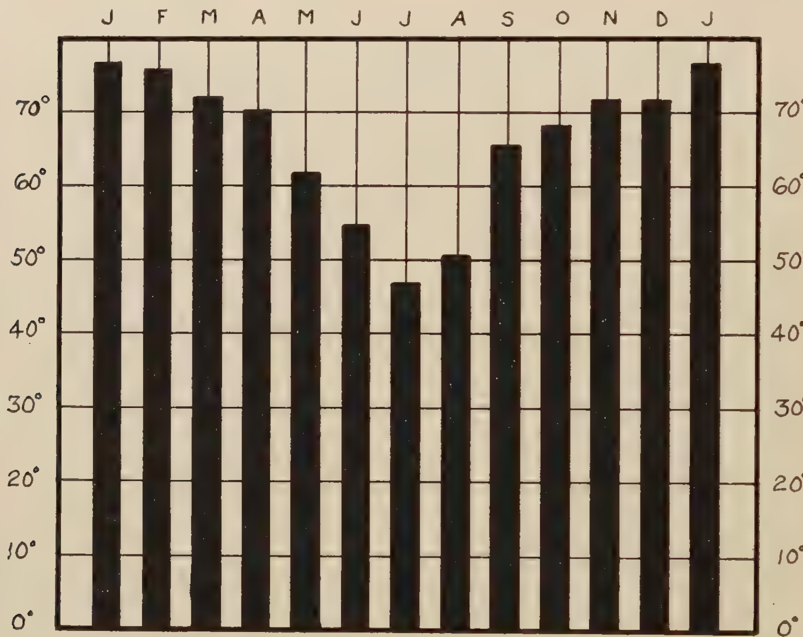


FIG. 18.—Greatest monthly range of temperature, 1871–1913 (see summary of Table XLVIII).

lower than the least range for any of the summer months. The greatest absolute range for the various months of the year is given in Fig. 18, and in the summary of the table, the latter also showing the highest and lowest temperatures and the years of the months in question.

The absolute daily range in temperature for the different days of the year has already been pointed out in connection with the discussion of daily extremes (p. 93), so that no further treatment of that phase of the subject is needed here. Table XLIX, however, gives

TABLE XLIX

GREATEST DAILY RANGES IN TEMPERATURE, MONTHLY AND ANNUAL, 1873–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1873	39	51	35	37	42	28	27	26	33	27	28	25	51
1874	25	25	22	26	31	27	33	23	22	31	34	31	34
1875	42	47	29	27	27	40	27	21	26	27	24	31	47
1876	44	32	30	28	22	27	22	20	20	28	25	30	44
1877	31	28	33	30	24	25	23	26	26	25	31	22	33
1878	26	21	30	23	20	20	20	21	30	24	26	21	30
1879	30	27	29	25	38	26	21	21	30	22	22	34	38
1880	27	25	26	31	33	21	20	24	22	28	24	38	38
1881	39	26	17	27	31	30	26	22	32	24	25	19	39
1882	29	24	28	33	28	28	20	20	24	21	32	23	33
1883	36	35	31	26	28	22	28	21	22	24	36	28	36
1884	25	34	26	33	31	24	23	19	24	24	42	44	44
1885	30	33	29	28	29	29	33	22	22	20	24	30	33
1886	37	40	32	25	34	23	23	23	27	23	37	30	40
1887	43	40	33	45	33	27	30	30	28	26	42	34	45
1888	51	29	30	36	35	35	28	27	28	32	23	26	51
1889	27	30	30	27	40	26	20	26	25	28	23	33	40
1890	29	22	26	35	35	29	24	27	23	21	33	25	35
1891	21	30	32	30	30	32	22	23	27	28	28	24	32
1892	19	32	30	31	28	29	21	23	28	28	22	20	32
1893	23	29	33	45	29	21	27	26	29	28	24	30	45
1894	23	23	29	34	35	36	31	26	23	30	30	21	36
1895	36	24	49	40	40	29	23	26	30	29	27	23	49
1896	25	24	24	36	33	26	25	25	25	25	44	22	44
1897	30	30	23	31	38	27	24	28	28	26	26	31	38
1898	25	28	30	28	30	28	30	24	20	23	37	32	37
1899	33	25	27	28	38	31	22	21	28	27	24	22	38
1900	29	52	27	27	36	22	25	24	23	29	24	30	52
1901	27	19	33	21	43	31	34	27	26	28	34	41	43
1902	35	23	25	36	31	34	25	24	30	23	22	26	36
1903	28	24	32	36	29	23	21	22	29	23	24	32	36
1904	27	42	37	28	29	29	23	24	26	23	25	32	42
1905	30	28	32	33	28	40	24	27	27	31	31	18	40
1906	31	27	23	31	27	25	22	21	19	30	26	39	39
1907	31	37	38	31	34	23	25	21	21	29	17	21	38
1908	25	29	36	29	33	25	23	23	35	27	27	26	36
1909	42	32	23	29	35	30	32	21	20	24	28	36	42
1910	27	26	36	37	29	24	22	23	24	25	29	20	37
1911*	34	23	32	18	35	31	24	20	24	25	42	27	42
1912*	29	19	25	31	39	33	24	27	26	23	20	26	39
1913*	32	26	33	29	29	41	29	25	24	21	30	29	41
Means	31.0	30.3	30.0	31.1	32.0	27.7	24.9	23.6	25.8	26.1	28.4	28.1	39.5

* Not included in means.

Table XLIX shows the greatest daily range of temperature, that is, the difference between the maximum and minimum for any one day, for each month and year.

SUMMARY OF TABLE XLIX

EXTREME DAILY RANGE IN TEMPERATURE, 1873–1913

Month	Day	Year	Range	Maximum	Minimum
January	13	1888	51°	42°	− 9°
February	8	1900	52°	62°	10°
March	29	1895	49°	80°	31°
April	12 7	1887 1893	45°	80° 84°	35° 39°
May	2	1901	43°	87°	44°
June	6	1913	41°	91°	50°
July	10	1901	34°	102°	68°
August	10	1887	30°	98°	68°
September	27	1908	35°	80°	45°
October	31	1888	32°	76°	44°
November	27	1896	44°	58°	14°
December	31	1884	44°	59°	15°
Year	Feb. 8	1900	52°	62°	10°

the greatest range occurring on any one day for the various months of the period of record. Were it not for the location of Chicago upon the shore of the lake, whose waters in winter are relatively warmer than the air, the daily ranges of the colder season could confidently be expected to be the greatest of any throughout the year. As a matter of fact, they are considerably greater than the daily ranges of mid-summer, but yet are not as great as those occurring in the months of April, May, and June. This greater fluctuation, due to the cool lake breezes (p. 43), is readily seen in the mean values at the bottom of the table, and also from the mean daily ranges in temperature based upon the range of every day in the official record, as given in Auxiliary Table D.

AUXILIARY TABLE D

MEAN DAILY RANGE IN TEMPERATURE

January	14°3	May	15°6	September	13°9
February	14°2	June	14°9	October	13°9
March	13°6	July	14°1	November	13°3
April	14°6	August	12°8	December	13°0
		For the year	13°9		

This greater fluctuation in April, May, and June is not because there are greater individual ranges in the spring than occur in January and February, but rather because the well-marked changes are more frequent at that time of the year. Great ranges during the winter months are usually caused by the advance of general cold waves which have escaped the moderating influence of the lake, as was the case with the large ranges of February, 1900, and January, 1888. In the spring, however, the greatest ranges are caused by a shifting of the wind from land to lake at a time when the temperature has risen to a markedly high degree. Such conditions occur every year in the spring months, because the water in the lake is then much colder than the air, and the difference is greater than at any other season; while in winter, months occasionally pass without any decided temperature changes.

The amount of range in temperature, of course, does not give any indication of the character of a month with respect to warmth or cold, but does describe the period with regard to changeableness. In fact, a very cold or very warm month will often have but little range in temperature if the cold or warmth has been persistent. For instance, in January, 1880, which was the warmest January on record at Chicago, the greatest daily range in temperature was only

27°, and the absolute range for the month was but 42°. There are, however, instances which present altogether different relations between the mean temperature and the range. In April, 1911, a very nearly normal month with respect to mean temperature, the greatest daily range was only 18°, and the absolute range was only 43°. There were but two other months in the history of the Weather Bureau office in Chicago in which at least one day did not exceed the record of April, 1911, in greatest daily range. Range is there-

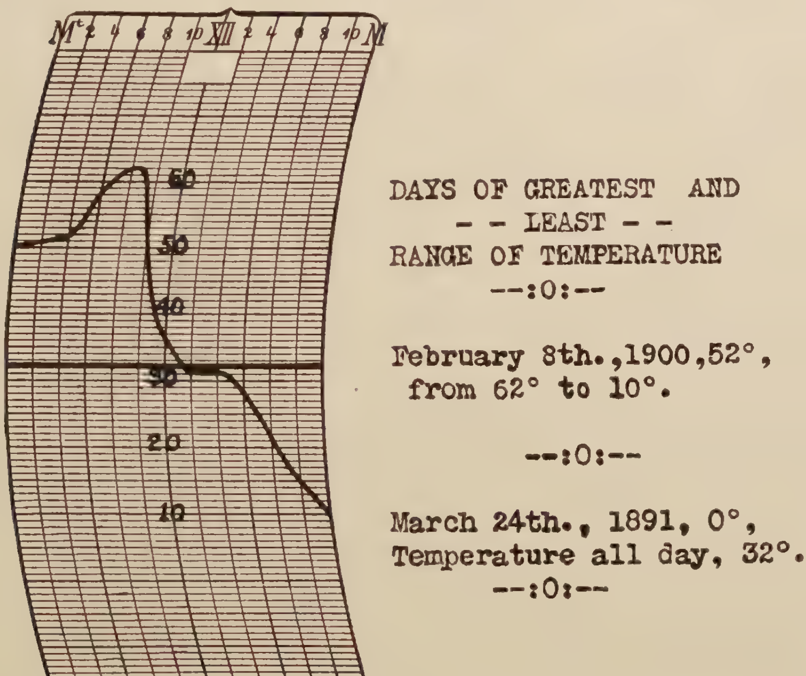


Fig. 19.

fore indicative rather of evenness of temperature than of the actual degree experienced, and in comparisons serves to point out equable climates.

Fig. 19 illustrates the widely varying character of temperature changes which have been experienced in Chicago. The curved line shows the hourly course of temperature on February 8, 1900, when the greatest daily range on record occurred, 52°, from a maximum of 62° to a minimum of 10°. This change actually occurred between the

hours of 8 A.M. and midnight, and did not require the entire space of the day to accomplish the fall. On the same graph, the straight line shows a temperature of 32° at every hour on March 24, 1891, there being not a single degree of variation throughout that time. Because of a strong northeast wind during the whole period on the latter date, and a totally clouded sky which shielded the atmosphere from the rays of the sun, the air assumed the temperature of the water in the lake, then at the freezing point, and maintained it from one end of the day to the other. It is the only instance of the kind within the Weather Bureau record, and is therefore the day of least range in temperature.

FREQUENCY OF MARKED RISES AND FALLS OF 20° OR MORE IN TEMPERATURE

1. *Within twenty-four hours.*—In the discussion of changes in temperature of stated amounts (p. 31) the mean temperature of the day was compared with that of the day following, while in the discussion of ranges just preceding this paragraph the change of temperature within the actual twenty-four hours of the day was used as a basis. A marked fall or rise, however, not infrequently extends from one day into the next, and the range for either day or the mean temperatures for both days, may give an entirely wrong idea of the real course of the temperature. For this reason the Weather Bureau has, since shortly after the beginning of its hourly records in 1890, taken note of marked changes in temperature for any period of twenty-four hours, whether such change occurs in one day or in portions of two days, and such portions of these data as are important to an understanding of Chicago's weather and climate are presented here.

Tables L and LI and Figs. 20 and 21 show the frequency of 24-hour rises and falls of 20° or more in temperature by months and years from 1893 to 1910, inclusive. The number of such falls is seen to be much greater than the number of rises, in the ratio of 532 to 348, the average annual occurrences being 29.6 for falls and 19.2 for rises. Ordinarily a rise in temperature is more gradual than a fall. For instance, with the coming of a cold wave the temperature falls rapidly, but after the crest of the wave has passed the change back to normal is usually gradual and requires a considerably longer time than did the drop to the minimum. The greatest number of these marked falls in temperature occurs during the winter and spring

months, just as the greatest daily and monthly ranges have been shown to occur (p. 118). In autumn, however, the number of marked

TABLE L

NUMBER OF 24-HOUR RISES IN TEMPERATURE OF 20° OR OVER, MONTHLY AND ANNUAL, 1893–1910

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893........	3	2	4	4	5	2	3	......	2	1	2	6	34
1894........	2	1	3	2	3	3	1	......	......	1	3	......	19
1895........	3	1	3	3	3	3	......	......	......	4	2	1	23
1896........	1	2	1	3	1	3	......	......	......	......	2	1	14
1897........	......	3	4	2	3	4	......	2	......	2	......	......	20
1898........	......	2	2	1	3	1	......	......	......	1	......	1	11
1899........	2	2	4	2	5	2	......	......	3	1	......	......	21
1900........	3	3	3	3	2	1	2	1	1	......	3	......	22
1901........	1	......	3	......	2	4	1	1	......	3	2	......	17
1902........	1	1	......	2	6	4	......	......	......	1	1	2	18
1903........	3	......	2	2	1	......	......	......	1	1	1	3	14
1904........	4	5	3	1	4	2	......	2	1	......	......	2	24
1905........	2	5	3	6	4	3	1	......	......	1	2	......	27
1906........	3	4	......	4	5	1	......	......	......	1	1	......	19
1907........	1	2	3	2	4	......	......	......	......	......	......	......	12
1908........	1	2	4	3	3	1	......	......	......	......	2	......	16
1909........	3	3	1	4	2	1	......	......	......	1	3	......	18
1910........	3	2	5	4	2	1	......	......	......	......	2	......	19
Total.......	36	40	48	48	58	36	8	6	8	18	26	16	348
Average.....	2.0	2.2	2.7	2.7	3.2	2.0	0.4	0.3	0.4	1.0	1.4	0.9	19.2

TABLE LI

NUMBER OF 24-HOUR FALLS IN TEMPERATURE OF 20° OR OVER, MONTHLY AND ANNUAL, 1893–1910

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893........	4	3	4	4	5	1	3	3	5	3	3	6	44
1894........	5	2	4	2	5	3	3	3	2	3	2	3	37
1895........	5	2	5	3	4	3	......	1	3	2	3	2	33
1896........	1	2	2	3	3	2	3	......	2	2	4	1	25
1897........	4	1	1	3	3	1	1	......	3	2	6	2	27
1898........	1	2	5	2	4	1	1	1	......	2	2	2	23
1899........	3	2	2	3	3	2	2	......	4	3	......	2	26
1900........	3	3	2	2	5	3	2	1	4	2	3	3	33
1901........	4	3	2	......	4	2	5	1	1	4	3	2	31
1902........	2	1	3	3	3	3	2	1	2	3	2	1	26
1903........	2	2	6	3	3	1	2	......	4	1	3	4	31
1904........	1	5	4	2	4	......	......	3	2	3	2	2	28
1905........	4	3	2	5	5	5	......	......	3	3	3	2	35
1906........	3	3	......	5	3	3	1	......	1	2	1	2	24
1907........	4	2	6	3	5	1	1	1	......	2	......	2	27
1908........	3	1	4	3	2	......	2	......	1	......	3	2	21
1909........	4	3	......	3	1	3	2	1	......	1	3	4	25
1910........	4	2	7	6	3	1	3	1	2	2	2	3	36
Total.......	57	42	59	55	65	35	33	17	39	40	45	45	532
Average.....	3.2	2.3	3.3	3.1	3.6	1.9	1.8	0.9	2.2	2.2	2.5	2.5	29.6

The average and total number of both 24-hour temperature rises and falls are graphically shown in Figs. 20 and 21.

falls is considerable, and this is to be expected, as the sun is then retreating to the winter solstice and the mean change is from warm to colder weather. So also, with the approach of the sun in spring

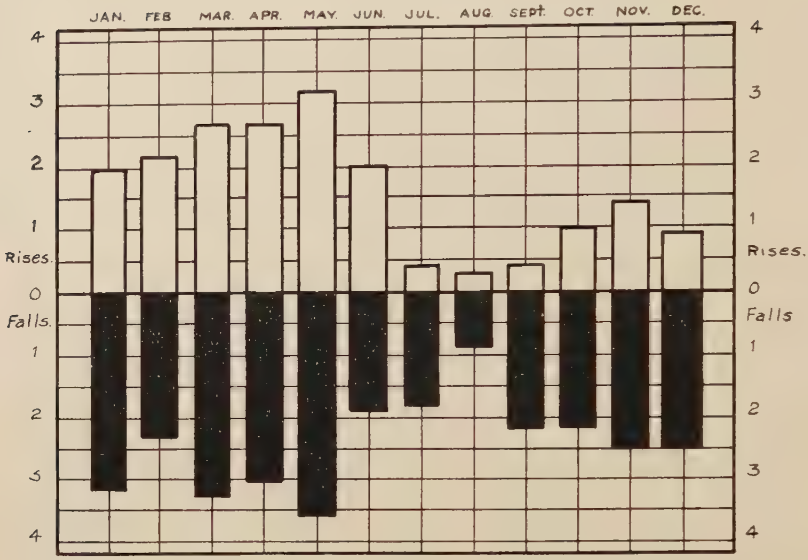


FIG. 20.—Average number of 24-hour temperature rises and falls of 20° or more. Record of 1893–1910, inclusive.

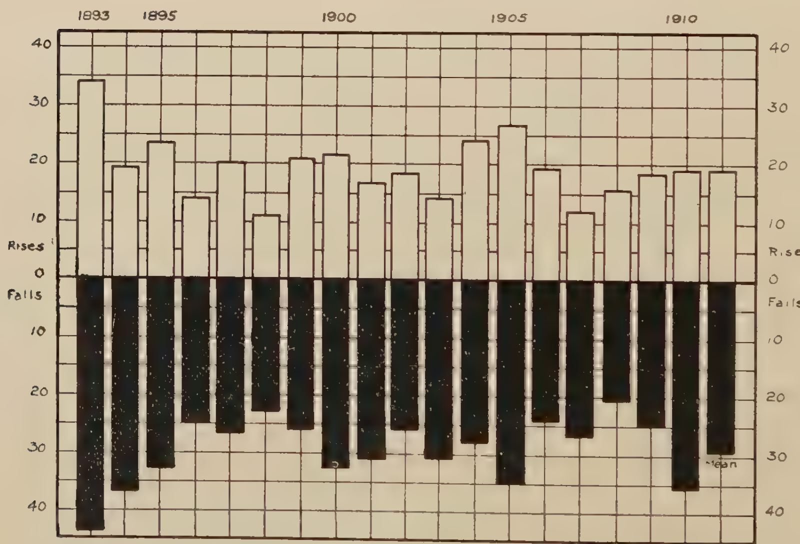


FIG. 21.—Annual frequency of 24-hour temperature changes of 20° or more. Record of 1893–1910, inclusive.

and early summer, marked rises in temperature are far more numerous than those of autumn and the remainder of the summer season. In May both marked rises and marked falls are more frequent than in the other months of the year, with an average occurrence of 3.2 and 3.6, respectively, and this fact, together with its comparatively great variability in mean temperature (p. 16) and its large daily ranges (p. 120) and its response to lake influence (p. 43), marks it as the most changeable month of the year so far as the weather of Chicago is concerned. On the other hand, practically the opposite of all these characteristics show August to be the month of most even temperature conditions, it having only one such marked rise in temperature in about three years, and one such marked fall annually. To be exact, the average yearly occurrence of these rises and falls is 0.3 and 0.9, respectively. Fig. 21 illustrates at a glance the great variation in the number of these changes from year to year, and the large excess in the number of marked falls over the marked rises in temperature. It has been previously pointed out that the temperature rises throughout a considerably shorter period of the year than it falls (p. 26), and as the record of marked falls and rises shows a large excess of changes of the first class, it might hastily be concluded that the statements are inconsistent with each other, as such a condition would indicate a constantly decreasing mean annual temperature, which is not the case (p. 5). It must be remembered in this connection that these records of marked changes include only those in which the temperature rose or fell 20° or more in twenty-four hours, leaving out of consideration altogether the changes in temperature of lesser amounts. Now, as a matter of fact, in changes of the latter class the rises far outnumber the falls, and so counteract the effect of the greater number of instances in which the temperature declines markedly. It is, however, impracticable to present tables showing these lesser changes, as space would have to be given the entire mass of hourly data on temperature. Individually, the year 1893 holds the record for the greatest number of marked rises and falls in temperature, with 34 and 44, respectively. The year 1898 was that of the least number of marked rises, its total being only 11, while the least number of marked falls during the period of record was experienced in 1908, when only 21 occurred. It will be noted from the tables that the warmer months of the year are comparatively free from rises in temperature of 20° or more during any twenty-four hours.

Table LII gives the number of days in each month and year in which these marked rises amounted to from 30° to 39° in any twenty-four hours, and Table LIII shows the actual change in degrees when

TABLE LII

Monthly and Annual Number of 24-Hour Rises in Temperature of 30° to 39°, 1893–1910

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893......	......	2	1	......	......	......	......	......	......	......	......	......	3
1894......	......	......	......	......	......	1	......	......	......	......	1	......	2
1895......	......	......	1	1	......	......	......	......	......	......	......	......	2
1896......	......	......	......	......	......	......	......	......	......	......	......	......	0
1897......	......	......	......	1	......	......	......	......	......	......	......	......	1
1898......	......	......	......	1	1	......	......	......	......	......	......	......	2
1899......	......	......	......	......	4	1	......	......	......	......	......	......	5
1900......	......	......	......	......	......	1	......	......	......	......	......	......	1
1901......	1	......	......	......	1	......	......	......	......	......	......	......	2
1902......	......	......	......	......	1	......	......	......	......	......	......	1	2
1903......	......	......	1	......	......	......	......	......	......	......	......	......	1
1904......	......	1	1	......	1	2	......	......	......	......	......	......	5
1905......	......	......	......	1	1	......	......	......	......	......	......	......	2
1906......	1	......	......	......	......	......	......	......	......	......	......	......	1
1907......	......	......	2	......	2	......	......	......	......	......	......	......	4
1908......	......	......	1	......	......	......	......	......	......	......	......	......	1
1909......	......	......	......	1	1	......	......	......	......	......	......	......	2
1910......	1	......	2	2	......	......	......	......	......	......	......	......	5
Total......	3	3	9	7	12	5	......	......	......	......	1	1	41

TABLE LIII

Number of 24-Hour Rises in Temperature of 40° or Over, 1893–1910, with the Amount in Each Case

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893......	......	......	......	43°	......	......	......	......	......	......	......	......	1
1894......	......	......	......	......	......	......	......	......	......	......	......	......	......
1895......	......	......	48°	......	41°	......	......	......	......	......	......	......	2
1896......	......	......	......	......	......	......	......	......	......	......	......	......	......
1897......	......	......	......	......	......	......	......	......	......	......	......	......	......
1898......	......	......	......	......	......	......	......	......	......	......	......	......	......
1899......	......	......	......	......	......	......	......	......	......	......	......	......	......
1900......	......	......	......	......	......	......	......	......	......	......	......	......	......
1901......	......	......	......	......	......	......	......	......	......	......	......	......	......
1902......	......	......	......	......	......	......	......	......	......	......	......	......	......
1903......	......	......	......	......	......	......	......	......	......	......	......	40°	1
1904......	......	......	......	......	......	......	......	......	......	......	......	......	......
1905......	......	......	......	......	......	......	......	......	......	......	......	......	......
1906......	......	......	......	......	......	......	......	......	......	......	......	......	......
1907......	......	......	......	......	......	......	......	......	......	......	......	......	......
1908......	......	......	......	......	......	......	......	......	......	......	......	......	......
1909......	......	......	......	......	......	......	......	......	......	......	......	......	......
1910......	......	......	......	......	......	......	......	......	......	......	......	......	......
Total......	......	......	1	1	1	......	......	......	......	......	......	1	4

the rise exceeded or equaled 40°. In only one instance has the temperature risen as much as 48° in any twenty-four hours (March 29–30, 1895), and there are only 4 days in the record which show a rise of 40° or over.

Table LIV gives the number of days in each month and year in which the marked falls amounted to from 30° to 39°. Table LV gives the same data for falls of from 40° to 49°, but shows the actual

amount of change in each case; and in a similar manner Table LVI shows the number of changes in which the fall was 50° or over in twenty-four hours, with the actual amount in degrees. A comparison of Tables LII and LIII with Tables LIV, LV, and LVI, shows

TABLE LIV

MONTHLY AND ANNUAL NUMBER OF 24-HOUR FALLS IN TEMPERATURE OF 30° TO 39°, 1893–1910

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893	2	......	......	1	1	1	......	......	......	......	......	3	8
1894	......	......	1	......	1	1	......	......	......	......	......	......	3
1895	1	......	1	1	1	......	......	......	2	......	......	......	6
1896	1	......	1	1	......	......	1	......	......	......	1	......	5
1897	3	......	......	1	2	......	......	......	......	1	1	......	8
1898	......	......	2	1	......	......	......	......	......	......	......	1	4
1899	2	1	1	......	1	......	......	......	......	......	......	......	5
1900	2	......	......	......	1	......	......	......	1	......	......	......	4
1901	1	......	2	......	2	......	1	......	......	1	1	......	8
1902	1	......	1	2	1	1	......	......	......	......	......	......	6
1903	1	......	2	1	......	......	......	......	......	......	......	1	5
1904	......	1	......	1	1	......	......	......	......	......	......	1	4
1905	1	2	2	1	......	2	......	......	......	......	1	......	9
1906	1	......	......	1	2	......	......	......	......	1	......	1	6
1907	1	1	......	1	2	......	......	......	......	......	......	......	5
1908	1	......	1	1	......	......	......	......	1	......	......	......	4
1909	1	1	......	......	......	2	......	......	......	......	......	1	5
1910	1	1	......	3	......	......	......	......	......	......	......	......	5
Total	20	7	14	16	15	7	2	0	4	3	4	8	100

TABLE LV

NUMBER OF 24-HOUR FALLS IN TEMPERATURE OF 40° TO 49°, 1893–1910, WITH THE AMOUNT IN EACH CASE

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893	......	45°	40°	40°	......	......	......	......	......	......	......	......	3
1894	......	......	......	......	44°	......	......	......	......	......	......	......	1
1895	42°	......	41°/42°	......	......	......	......	......	......	......	......	......	3
1896	......	......	......	......	......	......	......	......	......	......	44°	......	1
1897	......	......	......	40°	......	......	......	......	......	......	......	......	1
1898	......	......	......	......	......	......	......	......	......	......	......	......	0
1899	......	......	......	40°	......	......	......	......	......	......	......	......	1
1900	45°	42°	......	......	......	......	......	......	......	......	......	......	2
1901	......	......	......	......	43°	......	......	......	......	......	......	......	1
1902	41°	......	......	......	......	......	......	......	......	......	......	......	1
1903	......	......	......	47°/42°	......	......	......	......	......	......	......	45°	3
1904	......	44°	......	......	40°	......	......	......	......	......	......	......	2
1905	......	......	......	......	......	......	......	......	......	......	44°	......	1
1906	......	......	......	......	......	......	......	......	......	......	......	40°	1
1907	43°	......	42°	......	......	......	......	......	......	......	......	......	2
1908	......	......	......	......	......	......	......	......	......	......	......	41°	1
1909	43°	......	......	......	......	......	......	......	......	......	......	......	1
1910	......	......	......	42°	......	......	......	......	......	......	......	......	1
Total	5	3	4	6	3	......	......	......	......	......	2	3	26

plainly how the marked falls in temperature of each class predominate over marked rises of like amounts. In the first class of from 30° to 39° change, the record shows 100 falls to 41 rises during the period of 18 years; in the class of from 40° to 49° change, 26 falls to 4 rises; and while there have been 3 instances in which the temperature fell

50° or more in twenty-four hours, there has not been a single time in which the temperature rose 50° in that time. There has been one occurrence of a fall of more than 60° in twenty-four hours. This happened in November, 1911 (see Fig. 22), after the period shown in the tables, during the advent of the severe cold wave of the 11th-12th, chronicled by one of the city newspapers as the one time in the history of Chicago when "one man was overcome by heat and two others frozen to death within the short space of twenty-four hours." At 4 P.M. of November 11, 1911, the official thermometers stood at 74°. At 10 A.M. on the following morning the mercury had dropped through 60°, and by 12:30 P.M., $20\frac{1}{2}$ hours after its highest point of the day before, the instruments showed 13°, making the

TABLE LVI

NUMBER OF 24-HOUR FALLS IN TEMPERATURE OF 50° OR OVER, 1893–1910, WITH THE AMOUNT IN EACH CASE

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893													
1894													
1895													
1896													
1897													
1898											50°		1
1899													
1900		58°											1
1901												56°	1
1902													
1903													
1904													
1905													
1906													
1907													
1908													
1909													
1910													
Total		1									1	1	3

record fall of 61° during any 24-hour period covered by the observations of the Weather Bureau. Never before had a November 11 been so warm, and never before had a November 12 been so cold. No change of 30° or over has been observed in August in twenty-four hours, and the months of June to October, inclusive, appear to be exempt from any such changes of 40° or more.

Figs. 22 and 23 illustrate the hourly course of temperature during the great changes shown in Table LVI and of three of the four shown in Table LIII. The great fall in November, 1911, has been added to the former, and a marked rise in March, 1903, to the latter figure. The general similarity of movement in the temperature change during these pronounced rises and falls can be seen at a

glance. Usually the movement begins between sunrise and sunset of the first day, the maximum of the rise being reached during the afternoon of the second day, and the minimum of the fall during the early morning hours. The influence of night radiation in the case of the fall, and of the sun's rays during the following morning in the

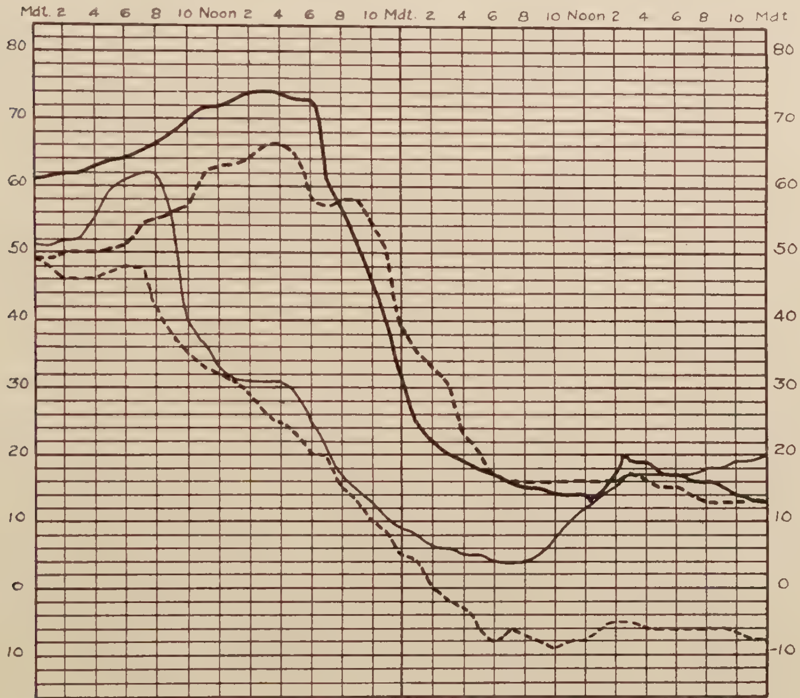


FIG. 22.—Greatest falls in temperature in any twenty-four consecutive hours or less, 1893–1911.

November 11–12, 1911, fall of 60°—from 74° to 14° in 18 hrs., 4:00 P.M. to 10:00 A.M., and to 13° at 12:30 P.M., a total fall of 61°.
February 8–9, 1900, fall of 58°—from 62° to 4° in 22 hrs., 8:00 A.M. to 6:00 A.M.
December 13–14, 1901, fall of 56°—from 48° to −8° in 23 hrs., 7:00 A.M. to 6:00 A.M.
November 21–22, 1898, fall of 50°—from 66° to 16° in 15 hrs., 4:00 P.M. to 7:00 A.M.

case of the rise, is quite plain from a study of the graphs, although, of course, the chief factor of control is the movement of the general storm areas past the city, with the attendant shifting winds that import air of greatly different temperatures.

Tables LVII and LVIII contain the greatest rises and falls in temperature for each month of the period of hourly record, when

such change has amounted to 20° or more, and has occurred in any 24-hour period or less. The data have no bearing on the greatest daily range for the month, as shown in Table XLIX, as already explained (p. 122).

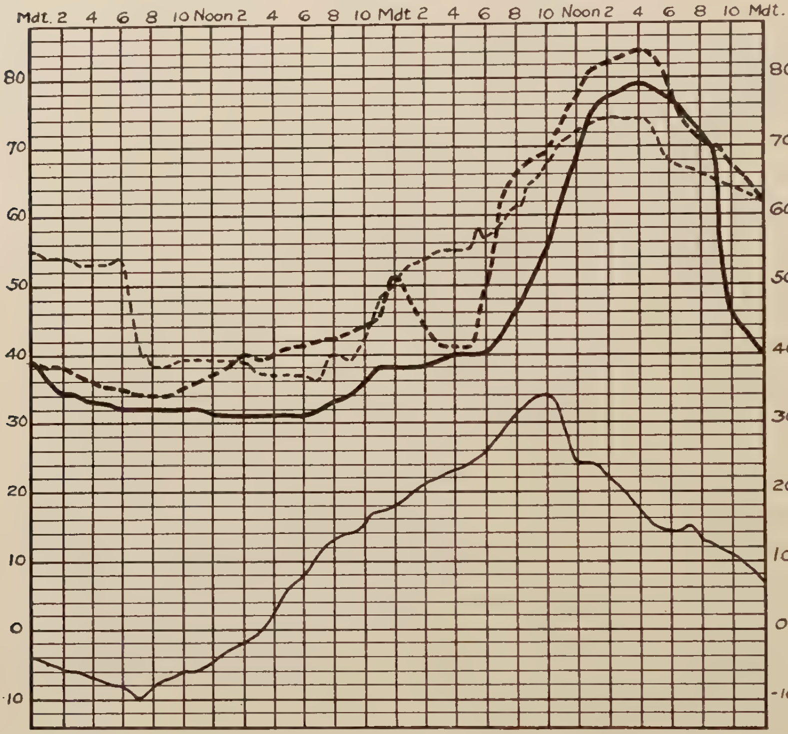


FIG. 23.—Greatest rises in temperature in any twenty-four consecutive hours or less, 1893–1910.

- March 28–29, 1895, rise of 48°—from 31° to 79° in 22 hrs., 6:00 P.M. to 4:00 P.M.
- April 6–7, 1893, rise of 43°—from 41° to 84° in 11 hrs., 5:00 A.M. to 4:00 P.M.
- December 26–27, 1903, rise of 40°—from −6° to 34° in 23 hrs., 11:00 A.M. to 10:00 A.M.
- March 17–18, 1903, rise of 38°—from 36° to 74° in 19 hrs., 7:00 P.M. to 2:00 P.M.

2. *Within one hour.*—It sometimes happens in the passage of storm areas, when conditions are such as to shift the wind suddenly, that much of the marked change in temperature ensuing occurs within a very short time, and the fall or rise thereafter to the extreme is much more gradual. Table LIX contains a list of the dates on which the temperature rose 15° or more within one hour, and Table LX shows the dates on which the temperature fell 20° or more within

one hour, from 1902 to 1911, inclusive. As rises in temperature are not so rapid as pronounced falls, the limit of 15° has been taken for Table LIX instead of 20°, a rise of the latter amount having occurred

TABLE LVII

Greatest 24-Hour Falls in Temperature, Monthly and Annual (Degrees), 1893–1910

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Greatest
1893.......	31	45	40	40	34	32	21	23	25	27	29	36	45
1894.......	27	23	31	25	44	36	26	25	24	24	27	23	44
1895.......	42	22	42	30	33	22	......	20	32	29	24	24	42
1896.......	34	27	31	33	26	22	31	......	27	27	44	20	44
1897.......	39	20	23	40	33	24	20	......	24	32	38	29	40
1898.......	23	27	35	33	29	21	21	22	......	23	50	35	50
1899.......	38	35	38	40	34	27	25	......	28	28	......	27	40
1900.......	45	58	22	27	34	27	23	22	33	28	26	29	58
1901.......	33	23	33	......	43	24	34	24	20	35	33	56	56
1902.......	41	23	35	35	39	31	26	21	27	24	25	26	41
1903.......	33	25	37	47	28	20	24	......	26	24	29	45	47
1904.......	29	44	29	38	40	......	......	27	26	29	23	36	44
1905.......	30	32	33	35	25	36	......	......	20	27	44	21	44
1906.......	33	27	......	31	32	29	22	......	20	31	28	40	40
1907.......	43	38	42	33	38	20	22	24	......	27	......	27	43
1908.......	33	29	33	38	24	......	26	......	31	......	27	41	41
1909.......	43	30	......	27	21	31	28	21	......	20	27	36	43
1910.......	31	32	28	42	27	24	22	23	23	29	26	26	42
Greatest....	45	58	42	47	44	36	34	27	33	35	50	56	58

No entry unless fall of 20° is recorded.

TABLE LVIII

Greatest 24-Hour Rises in Temperature, Monthly and Annual (Degrees), 1893–1910

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Greatest
1893.......	25	33	30	44	25	22	25	......	24	23	24	29	44
1894.......	23	28	25	26	28	30	22	......	......	20	31	......	31
1895.......	24	20	48	39	41	23	......	......	......	26	24	20	48
1896.......	21	24	23	28	28	24	......	......	......	......	22	24	28
1897.......	......	29	25	30	25	24	......	21	......	23	......	......	30
1898.......	......	25	28	30	30	25	......	......	......	20	......	26	30
1899.......	26	29	24	28	31	32	......	......	25	28	......	......	22
1900.......	25	21	29	24	22	30	24	24	24	......	24	......	30
1901.......	32	......	25	......	30	29	21	21	......	24	25	......	32
1902.......	20	23	......	28	32	28	......	......	......	20	22	30	32
1903.......	23	......	38	28	24	......	......	......	22	23	25	40	40
1904.......	27	35	30	29	33	30	......	23	22	......	......	27	35
1905.......	25	24	28	31	33	24	20	......	......	24	27	......	33
1906.......	31	24	......	24	26	20	......	......	......	22	25	......	31
1907.......	20	24	38	23	37	......	......	......	......	......	......	......	38
1908.......	22	25	31	29	28	21	......	......	......	......	22	......	31
1909.......	22	26	25	30	39	26	......	......	......	22	24	......	39
1910.......	30	22	30	33	29	23	......	......	......	......	24	......	33
Greatest....	32	35	48	44	41	32	25	24	25	28	31	40	48

No entry unless rise of 20° is recorded.

in one hour only once in the period of 10 years shown. This instance occurred on March 26, 1907, from 3:15 to 4:15 p.m., when the rise was from 45° to 65°, and is the most pronounced rise of the record.

The change was due to a shifting of the wind from the lake to a southerly direction. The rise on May 10, 1911, was occasioned by similar conditions, the temperature rising 18° during the first hour, and continuing thereafter at such a rate that at the close of the second hour the total rise amounted to 27°. When the change in temperature is due to lake effect, by far the greater portion, whether rise or fall, occurs during the first hour. Marked falls in temperature,

TABLE LIX

Temperature Rises of 15° or Over in 1 Hour, 1902–11

Date	Time			Temperature Rise (Degrees)		
	From	To	Length	From	To	Amount
1902 June 12	10:00 A.M.	11:00 A.M.	1 hr.	65	80	15
1907 March 26	3:15 P.M.	4:15 P.M.	1 hr.	45	65	20
April 24	3:00 P.M.	4:00 P.M.	1 hr.	52	70	18
1908 March 27	7:50 P.M.	8:50 P.M.	1 hr.	46	62	16
1909 April 6	10:30 A.M.	11:30 A.M.	1 hr.	45	62	17
1910 May 22	12:00 M.	1:00 P.M.	1 hr.	61	76	15
1911 May 10	8:50 A.M.	9:50 A.M.	1 hr.	56	74	18
May 10	8:50 A.M.	10:50 A.M.	2 hrs.	56	83	27

TABLE LX

Temperature Falls of 20° or Over in 1 Hour, 1902–11

Date	Time			Temperature Fall (Degrees)		
	From	To	Length	From	To	Amount
1902 May 3	4:00 P.M.	5:00 P.M.	1 hr.	76	56	20
June 10	1:00 P.M.	2:00 P.M.	1 hr.	80	60	20
June 15	12:00 M.	1:00 P.M.	1 hr.	86	66	20
1904 May 26	12:00 M.	1:00 P.M.	1 hr.	65	45	20
1905 March 31	1:00 P.M.	2:00 P.M.	1 hr.	67	46	21
1906 May 26	7:45 A.M.	8:45 A.M.	1 hr.	71	46	25
June 29	2:30 P.M.	3:30 P.M.	1 hr.	89	67	22
1907 May 26	4:00 P.M.	5:00 P.M.	1 hr.	70	50	20
August 1	2:55 P.M.	3:05 P.M.	10 min.	82	63	19
1908 March 26	1:00 P.M.	2:00 P.M.	1 hr.	71	41	30
April 6	7:00 P.M.	8:00 P.M.	1 hr.	63	43	20
May 12	11:00 P.M.	12:00 MDT.	1 hr.	72	49	23
1910 April 11	11:00 A.M.	12:00 M.	1 hr.	78	50	28
1911 June 4	8:50 P.M.	9:50 P.M.	1 hr.	85	65	20
July 15	6:10 P.M.	7:10 P.M.	1 hr.	89	68	21

as will be seen from Table LX, are far more abrupt and frequent than the rises, there being a number of dates in the 10-year period when the fall exceeded 20° in one hour. The greatest change of this kind occurred on March 26, 1908, when the temperature fell 30° between 1 and 2 P.M., from 71° to 41°.

The following data, giving further particulars of the days on which the most pronounced short-time changes occurred, will furnish the necessary information for a more extended study of the subject:

MAY 10, 1911. The greatest rise in temperature was 27° in two hours, from 8:50 to 10:50 A.M., rising from 56° to 83°. The rise thereafter was gradual, reaching 87° at 2 P.M. The wind had been easterly up to 8 A.M., but shifted to south during the following hour. The minimum temperature was 52° at 5 A.M., making the range for the day 35°.

MARCH 26, 1908. The temperature fell 30° from 71° at 1 P.M. to 41° at 2 P.M., continuing until 37° was reached at 5 P.M., thus making a drop of 34° in 4 hours. The minimum was 35° at midnight, and the range for the day therefore 36°. The wind was high from the southwest during the morning, but changed to north shortly after 1 P.M., and continued with only slightly diminished velocity.

APRIL 11, 1910. The temperature fell 28° from 78° at 11 A.M. to 50° at 12 noon, continuing until 46° was reached at 3 P.M., thus making a drop of 32° in 4 hours. The minimum was 41° at midnight, and the range for the day therefore 37°. The wind was light from the south and west up to 11 A.M., when it changed to north and increased in velocity, reaching a maximum of 30 miles an hour at 11:50 A.M.

These great rises and falls in temperature within a single hour, as shown in the tables, occur almost invariably in the spring and early summer. The changes in twenty-four hours accompanying the cold waves of the winter season are far greater than those of any other portion of the year, but the fall hour by hour is usually small as compared with the changes due to shifting winds in spring. For example, in February, 1900, the temperature fell 58° on the 8th–9th, from 62° at 8 A.M. of the 8th to 4° at 4 A.M. of the 9th, yet the greatest hourly change was but 13°, and that amount of fall occurred only once, the next largest being 9°, with none other greater than 4°. During the cold wave of November 11–12, 1911 (p. 128), the greatest of any of the hourly falls was but 12°.

HOURLY TEMPERATURE CONDITIONS

1. *Mean hourly temperatures by months.*—The daily cycle of change from the highest temperature of the afternoon to the lowest during the early morning hours, and back again, is familiar to everyone. Broken as is this cycle by the passage of storm areas, it is sufficiently distinct to impress even the most casual observer of weather conditions, and when sought in the average values of temperature shows a surprisingly even daily movement and regularity of oscillation through the months of the year, as will be apparent from a study of Table LXI and Fig. 24, which have been prepared from the hourly temperature records from 1890 to 1910, inclusive.

TABLE LXI

MEAN HOURLY TEMPERATURES, 1890–1910

Period	Hour Ending																								Mean
	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Mdt.	
January	23.9	23.7	23.3	23.0	22.8	22.7	22.8	22.7	23.2	24.2	25.3	26.3	27.0	27.6	27.9	27.8	27.5	26.9	26.5	25.9	25.5	25.1	24.7	24.3	25.0
February	22.5	22.0	21.6	21.3	21.0	20.8	20.9	21.1	21.9	23.0	24.2	25.2	26.0	26.7	27.2	27.4	27.0	26.4	25.9	25.2	24.7	24.2	23.7	23.1	23.9
March	33.9	33.4	33.0	32.4	32.3	32.1	32.4	33.0	34.0	35.4	36.0	36.7	37.1	37.9	38.3	38.5	38.2	37.5	37.0	36.4	36.0	35.5	35.0	34.2	35.3
April	44.6	44.1	43.6	43.0	42.7	42.5	43.4	44.4	45.5	46.5	47.4	48.0	48.4	49.0	49.3	49.3	48.8	48.0	47.2	46.7	46.4	46.1	45.7	45.0	46.1
May	54.1	53.5	53.1	52.5	52.1	52.2	53.7	55.3	56.3	57.4	58.2	58.6	59.3	59.8	60.1	59.9	59.5	58.5	57.8	56.9	56.3	55.8	55.3	54.6	56.3
June	64.1	63.6	63.0	62.5	62.2	62.7	64.4	65.8	67.2	68.1	68.9	69.4	70.0	70.3	70.2	70.0	69.6	68.8	67.8	66.9	66.4	65.8	65.2	64.8	66.6
July	69.8	69.2	68.6	68.0	67.7	68.2	69.7	71.2	72.7	73.7	74.5	74.9	75.4	75.7	76.0	76.0	75.8	75.1	74.2	73.0	72.2	71.6	71.0	70.4	72.3
August	69.2	68.5	67.9	67.4	66.9	67.0	68.3	70.0	71.5	72.5	73.4	74.0	74.4	74.8	75.2	75.1	74.6	73.9	72.8	72.0	71.5	70.9	70.3	69.8	71.3
September	63.4	62.7	62.1	61.4	60.8	60.5	61.3	62.8	64.6	66.3	67.6	68.4	68.9	69.4	69.7	69.7	69.2	68.2	67.3	66.5	65.8	65.0	64.4	63.9	65.4
October	51.7	51.1	50.5	49.9	49.4	49.1	49.4	50.5	52.2	54.1	55.5	56.4	57.2	57.8	58.2	58.0	57.3	56.3	55.5	54.7	54.0	53.3	52.7	52.3	53.6
November	38.1	37.6	37.2	36.7	36.5	36.3	36.4	36.7	37.7	39.3	40.5	41.5	42.3	42.8	43.2	42.9	42.3	41.5	41.0	40.3	39.7	39.2	38.7	38.5	39.4
December	27.1	26.8	26.6	26.3	26.1	25.9	26.1	26.1	26.6	27.7	28.9	29.8	30.5	31.1	31.3	31.1	30.6	30.1	29.7	29.1	28.6	28.2	27.8	27.5	28.3
Spring	44.2	43.7	43.2	42.6	42.4	42.3	43.2	44.2	45.3	46.4	47.2	47.8	48.3	48.9	49.2	49.2	49.0	48.0	47.3	46.7	46.2	45.8	45.3	44.6	45.9
Summer	67.7	67.1	66.5	66.0	65.6	65.8	67.5	69.0	70.5	71.4	72.3	72.8	73.3	73.6	73.8	73.4	73.3	72.6	71.6	70.6	70.0	69.4	68.8	68.3	70.1
Autumn	51.1	50.3	49.9	49.1	48.9	48.6	49.0	50.0	51.5	53.2	54.5	55.4	56.1	56.7	57.0	56.9	56.3	55.3	54.6	53.8	53.2	52.5	51.9	51.6	52.8
Winter	24.5	24.0	23.8	23.5	23.3	23.1	23.3	23.3	23.9	25.0	26.1	27.1	27.8	28.5	28.8	28.8	28.4	27.8	27.4	26.7	26.3	25.8	25.4	25.0	25.7
Annual	46.9	46.4	45.9	45.4	45.0	45.0	45.8	46.6	47.8	49.0	50.0	50.8	51.4	51.9	52.1	52.1	51.7	50.9	50.2	49.5	49.8	48.4	47.9	47.4	48.6

Table LXI contains the mean hourly temperature by months, seasons, and for the year, 1890–1910. These readings are taken from traces of a Richard thermograph, corrected daily by readings of the maximum and minimum temperature and also by the observed readings at 7:00 A.M. and 7:00 P.M. The hourly values are shown graphically in Fig. 24.

In the discussion of maximum and minimum temperatures (p. 26), it was shown that the highest temperatures of the year occur on July 16, and the lowest on February 1, the mean temperature, of course, occurring once on either side of these two dates. The present table and graph indicate the time of day at which the highest and lowest temperatures usually occur for each of the months of the year, and also the hours on either side at which the mean hourly temperature of the month is experienced. The warmest hours of the year are 3 and 4 P.M. in July, with an average temperature of 76°, and the coldest is 6 A.M. in February, with an average of 20°.8. The mean hourly temperature of the month, shown in the right-hand

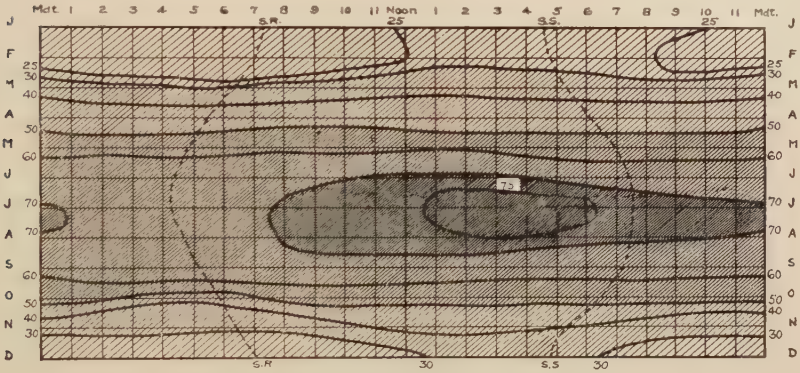


FIG. 24.—Mean hourly temperature.

Fig. 24 shows the average distribution of temperature for the day and year, based upon hourly thermograph readings for a period of 21 years, 1890–1910 (see Table LXI). The line inclosing the area of deepest shading shows the time of occurrence of the highest temperatures for the day and year, the shading decreasing with the decrease of temperature, and the area of lightest shading indicating the time of occurrence of the lowest temperatures for the day and year. The dotted lines, *S.R.* and *S.S.*, show the time of sunrise and sunset.

column in the table, is also the mean temperature for the month for the period from 1890 to 1910. The values, however, do not coincide with the means shown in Table I (p. 8) for two reasons: the period of observations on which the values in Table LXI are based is only about one-half the length of that used in Table I; and again, the values of the former are calculated from the hourly temperatures, while those of the latter are calculated from the maximum and minimum readings, and there is a slight difference in result between the two methods (p. 3). Fig. 24 will be found very useful in locating definitely the portions of the day in which any given temperature is likely to occur. For instance, the temperature averages 75° or

over from 1 to 6 P.M. in July, and from 3 to 4 P.M in August, as shown by the 75°-line in the drawing, and an average temperature of between 20° and 25° prevails in January and February from two or three hours before midnight until about noon. The temperatures average more than 60° at all hours of the day throughout June, July, August, and September. In similar manner the daily and yearly prevalence of any temperature can be determined. While the hourly annual and seasonal values have been added to the table, their use in comparisons is limited, especially in the case of spring and autumn, when temperatures are changing rapidly through a wide range.

2. *Temperature phases.*—It is evident that the hourly temperatures in their movement through the diurnal cycle referred to in th previous paragraph must touch the important values of the day in the following order: minimum, mean, maximum, mean. It is therefore of much consequence that the times throughout the months of the year at which these readings ordinarily occur be determined with greater accuracy than is done in Table LXI. The number of times the mean hourly values in question have occurred at the different hours of the day are set forth in Table LXII, and the average times of occurrence have been equated therefrom, as shown. For the year as a whole, the minimum temperature of the day is reached at 6 A.M., and the temperature rising thereafter passes the daily mean at 9:55 A.M., and continues to the maximum of the day at 3:25 P.M. Thereafter there is a fall past the daily mean at 9:40 P.M. to the minimum of the following day. It will be seen, however, that throughout the various months these successive phases seldom occur at the mean yearly time, although there is comparatively slight variation in the time of occurrence of the maximum temperature. The minimum, on the other hand, occurs as early as 4:50 A.M. in June, and as late as 6:35 A.M. in January, varying regularly with the rising of the sun. The apparent discrepancy in December is caused by the occurrence of the mean minimum once at 1 A.M. and once at 2 A.M., which advances the average time considerably, as computed from the data. The variation of the time of occurrence of the mean temperature of the day is also well marked, being much earlier in the summer than in the winter months.

Under normal conditions, that is, when not subject to storm and cold wave conditions or otherwise, and when not subject to direct insolation, any given portion of the surface of the earth will cool

TABLE LXII

TEMPERATURE PHASES, 1890–1910

MONTH	MINIMUM Frequency A.M. 3:00	4:00	5:00	6:00	7:00	8:00	MINIMUM Average Time	FIRST MEAN Frequency A.M. 8:00	9:00	10:00	11:00	FIRST MEAN Average Time	MAXIMUM Frequency P.M. 1:00	2:00	3:00	4:00	5:00	MAXIMUM Average Time	SECOND MEAN Frequency P.M. 7:00	8:00	9:00	10:00	11:00	MDT. 12:00	SECOND MEAN Average Time	TOTAL AMPLITUDE
Jan.	.....	.....	6	7	3	9	6:35	.....	.....	5	17	10:45	.....	1	13	12	1	3:30	.....	.....	4	12	7	3	10:20	8:55
Feb.	1	3	3	10	7	5	6:10	.....	4	18	1	10:50	.....	.....	6	18	.....	3:45	.....	.....	.....	9	9	2§	10:45	9:35
Mar.	.....	2	1	16	6	.....	6:00	.....	2	12	8	10:15	.....	.....	8	16	6	4:00	.....	1	4	8	6	4§	10:30	10:00
April	.....	.....	9	15	.....	.....	5:40	.....	10	13	.....	9:35	2	.....	7	12	2	3:30	2‡	4	4	9	6	.....	9:25	9:50
May	.....	1	15	7	.....	.....	5:15	2	18	2	.....	9:00	.....	4	8	10	.....	3.15	.....	6	11	5	2	.....	9:15	10:00
June	.....	5	17	1	.....	.....	4.50	8	12	1	.....	8:40	4†	6	5	5	3	2:45	2	8	7	3	1	.....	8:40	9:55
July	.....	.....	21	2	.....	.....	5:05	7	14	.....	.....	8:40	.....	3	7	13	2	3:35	.....	7	11	3	.....	.....	8:50	10:30
Aug.	.....	.....	13	12	.....	.....	5:30	3	15	3	.....	9:00	1	2	9	11	3	3:30	.....	3	10	10	.....	.....	9:20	10:00
Sept.	.....	.....	.....	21	.....	.....	6:00	.....	13	8	.....	9:25	.....	.....	15	8	2	3:30	.....	.....	13	7	1	.....	9:25	9:30
Oct.	.....	.....	1	19	3	.....	6:05	.....	4	16	1	9:50	.....	1	15	8	.....	3:20	.....	.....	8	13	1	1	9:55	9:15
Nov.	.....	1	3	16	6	3	6:15	.....	.....	15	6	10:20	1	.....	19	4	1	3:10	.....	2	11	4	3	2	9:40	8:55
Dec.	3*	1	6	12	3	5	5.35	.....	.....	11	10	10:30	1	4	17	6	.....	3:00	.....	2	8	9	4	.....	9:40	9:25
Year	0	1	8	12	2	2	6:00	2	8	9	4	9:55	1	2	11	10	2	3:25	0	3	8	8	3	1	9:40	9:25

* 1 at 1:00 A.M. and 1 at 2:00 A.M. † 1 at 12:00 noon. ‡ 1 at 1:00 A.M. §1 at 6:00 P.M.

Table LXII shows the average time of occurrence of the minimum and maximum temperature of the day for each month and year; the hours in the morning and afternoon when the average temperature of the day is most likely to occur; the frequency of occurrence of these phases at given hours; and the average number of hours between the times of occurrence of the minimum and the maximum temperatures of the day. These values are based upon hourly observations from 1890 to 1910 (see Fig. 24).

off at a more or less rapid rate, depending upon cloudiness, convection, etc. This loss of heat, represented by the lowering of the temperature, goes on all the time, although the rate may vary considerably, and ordinarily increases rapidly with rising temperature. Normally a minimum temperature will be reached at sunrise or shortly thereafter, the mercury rising when the surface of the ground begins to receive heat by radiation. The amount received is small at first, but increases rapidly as the sun attains altitude, and although the loss of heat proceeds at the usual or even more rapid rate, nevertheless the temperature rises steadily because the amount of heat received exceeds that lost. When the sun reaches the meridian insolation is at a maximum, but thereafter diminishes with increasing rapidity as the sun declines. The temperature, however, continues to rise slowly, and attains its maximum some hours later, when the diminished intensity of insolation is then equal to the rapid losses by radiation, convection, etc. Actual cooling then sets in, notwithstanding that heat continues to be received up to sunset and in quantities that in the morning hours sufficed to cause a rapid rise in temperature.

We thus find that although on the average the sun shines during 12 hours or more each day, yet its heating power is not adequate to maintain a rising temperature for more than about 9 hours. Not only is the heat received during the remaining 3 hours lost as rapidly as received, but in addition a portion of that previously stored is carried away by the convection and radiation process. This 3-hour period being added to the 12 hours of darkness during which heating from outside sources is inappreciable gives 15 hours of cooling for the entire day.

After the minimum of the yearly temperature is passed, and as the sun advances in its northward course, the loss of temperature each day during the hours of cooling is a little less than the rise of temperature under the influence of the sunshine, so that little by little the daily mean rises, whereas the reverse occurs while the sun is returning southward and daily means are on the average steadily diminishing.

3. *Hourly departures from mean hourly temperatures.*—The discussion of hourly values in the preceding paragraphs is supplemented by the data contained in Table LXIII, which shows the difference between the mean temperature of any hour and the mean hourly temperature of the month in which it occurs. In this table the least

TABLE LXIII

HOURLY DEPARTURES FROM THE MEAN OF THE HOURLY TEMPERATURES, 1890–1910

Month	Hour Ending																						
	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Mdt.
January	−1.1	−1.3	−1.7	−2.0	−2.2	−2.3	−2.2	−2.3	−1.8	−0.8	+0.3	+1.3	+2.0	+2.6	+2.9	+2.8	+2.5	+1.9	+1.5	+0.9	+0.5	+0.1	−0.3	−0.7
February	−1.4	−1.9	−2.3	−2.6	−2.9	−3.1	−3.0	−2.8	−2.0	−0.9	+0.3	+1.3	+2.1	+2.8	+3.3	+3.5	+3.1	+2.5	+2.0	+1.3	+0.8	+0.3	−0.2	−0.8
March	−1.4	−1.9	−2.3	−2.9	−3.0	−3.2	−2.9	−2.3	−1.3	+0.1	+0.7	+1.4	+1.8	+2.6	+3.0	+3.2	+2.9	+2.2	+1.7	+1.1	+0.7	+0.2	−0.3	−1.1
April	−1.5	−2.0	−2.5	−3.1	−3.4	−3.6	−2.7	−1.7	−0.6	+0.4	+1.3	+1.9	+2.3	+2.9	+3.2	+3.2	+2.7	+1.9	+1.1	+0.6	+0.3	0.0	−0.4	−1.1
May	−2.2	−2.8	−3.2	−3.8	−4.2	−4.1	−2.6	−1.0	0.0	+1.1	+2.1	+2.3	+3.0	+3.5	+3.8	+3.6	+3.2	+2.3	+1.5	+0.6	0.0	−0.5	−1.0	−1.7
June	−2.5	−3.0	−3.6	−4.1	−4.4	−3.9	−2.2	−0.8	+0.6	+1.5	+2.3	+2.8	+3.4	+3.7	+3.6	+3.4	+3.0	+2.2	+1.8	+0.3	−0.2	−0.8	−1.4	−1.8
July	−2.5	−3.1	−3.7	−4.3	−4.6	−4.1	−2.6	−1.1	+0.4	+1.4	+2.2	+2.6	+3.1	+3.4	+3.7	+3.7	+3.5	+2.8	+1.9	+0.7	−0.1	−0.7	−1.3	−1.9
August	−2.1	−2.8	−3.4	−3.9	−4.4	−4.3	−3.0	−1.3	+0.2	+1.2	+2.1	+2.7	+3.1	+3.5	+3.9	+3.8	+3.3	+2.6	+1.5	+0.7	+0.2	−0.4	−1.0	−1.5
September	−2.0	−2.7	−3.3	−4.0	−4.6	−4.9	−4.1	−2.6	−0.8	+0.9	+2.2	+3.0	+3.5	+4.0	+4.3	+4.3	+3.8	+2.8	+1.9	+1.1	+0.4	−0.4	−1.0	−1.5
October	−1.9	−2.5	−3.1	−3.7	−4.2	−4.5	−4.2	−3.1	−1.4	+0.5	+1.9	+2.8	+3.6	+4.2	+4.6	+4.4	+3.7	+2.7	+1.9	+1.1	+0.4	−0.3	−0.9	−1.3
November	−1.3	−1.8	−2.2	−2.7	−2.9	−3.1	−3.0	−2.7	−1.7	−0.1	+1.1	+2.1	+2.9	+3.4	+3.8	+3.5	+2.9	+2.1	+1.6	+0.9	+0.3	−0.2	−0.7	−0.9
December	−1.2	−1.5	−1.7	−2.0	−2.2	−2.4	−2.2	−2.2	−1.7	−0.6	+0.6	+1.5	+2.2	+2.8	+3.0	+2.8	+2.3	+1.8	+1.4	+0.8	+0.3	−0.1	−0.5	−0.8

Table LXIII contains the hourly departures from the mean of the hourly temperatures based upon Table LXI.

TABLE LXIV

Mean Hourly Changes in Temperature, 1890–1910

Month	Hour Ending																							
	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Mdt.
January	−0.4	−0.2	−0.4	−0.3	−0.2	−0 1	+0.1	−0.1	+0.5	+1.0	+1.1	+1.0	+0.7	+0.6	+0.3	−0.1	−0.3	−0.4	−0.4	−0.6	−0.4	−0.4	−0.4	−0.4
February	−0.6	−0.5	−0.4	−0.3	−0.3	−0.2	+0.1	+0.2	+0.8	+1.1	+1.2	+1.0	+0.8	+0.7	+0.5	+0.2	−0.4	−0.6	−0.5	−0.7	−0.5	−0.5	−0.5	−0.6
March	−0.3	−0.5	−0.4	−0.6	−0.1	−0.2	+0.3	+0.6	+1.0	+1.4	+0.6	+0.7	+0.4	+0.8	+0.4	+0.2	−0.3	−0.7	−0.5	−0.6	−0.4	−0.5	−0.5	−0.8
April	−0.4	−0.5	−0.5	−0.6	−0.3	−0.2	+0.9	+1.0	+1.1	+1.0	+0.9	+0.6	+0.4	+0.6	+0.3	0.0	−0.5	−0.8	−0.8	−0.5	−0.3	−0.3	−0.4	−0.7
May	−0.5	−0.6	−0.4	−0.6	−0.4	+0.1	+1.5	+1.6	+1.0	+1.1	+0.8	+0.4	+0.7	+0.5	+0.3	−0.2	−0.4	−0.9	−0.8	−0.9	−0.6	−0.5	−0.5	−0.7
June	−0.7	−0.5	−0.6	−0.5	−0.3	+0.5	+1.7	+1.4	+1.4	+0.9	+0.8	+0.5	+0.6	+0.3	−0.1	−0.2	−0.4	−0.8	−1.0	−0.9	−0.5	−0.6	−0.6	−0.4
July	−0.6	−0.6	−0.6	−0.6	−0.3	+0.5	+1.5	+1.5	+1.5	+1.0	+0.8	+0.4	+0.5	+0.3	+0.3	0.0	−0.2	−0.7	−0.9	−1.2	−0.8	−0.6	−0.6	−0.6
August	−0.6	−0.7	−0.6	−0.5	−0.5	+0.1	+1.3	+1.7	+1.5	+1.0	+0.9	+0.6	+0.4	+0.4	+0.4	−0.1	−0.5	−0.7	−1.1	−0.8	−0.5	−0.6	−0.6	−0.5
September	−0.5	−0.7	−0.6	−0.7	−0.6	−0.3	+0.8	+1.5	+1.8	+1.7	+1.3	+0.8	+0.5	+0.5	+0.3	0.0	−0.5	−1.0	−0.9	−0.8	−0.7	−0.8	−0.6	−0.5
October	−0.6	−0.6	−0.6	−0.6	−0.5	−0.3	+0.3	+1.1	+1.7	+1.9	+1.4	+0.9	+0.8	+0.6	+0.4	−0.2	−0.7	−1.0	−0.8	−0.8	−0.7	−0.7	−0.6	−0.4
November	−0.4	−0.5	−0.4	−0.5	−0.2	−0.2	+0.1	+0.3	+1.0	+1.6	+1.2	+1.0	+0.8	+0.5	+0.4	−0.3	−0.6	−0.8	−0.5	−0.7	−0.6	−0.5	−0.5	−0.2
December	−0.4	−0.3	−0.2	−0.3	−0.2	−0.2	+0.2	0.0	+0.5	+1.1	+1.2	+0.9	+0.7	+0.6	+0.2	−0.2	−0.5	−0.5	−0.4	−0.6	−0.5	−0.4	−0.4	−0.3
Annual	−0.5	−0.5	−0.5	−0.5	−0.3	0.0	+0.7	+0.9	+1.2	+1.2	+1.0	+0.7	+0.6	+0.5	+0.3	−0.1	−0.4	−0.7	−0.7	−0.8	−0.5	−0.5	−0.5	−0.5

Table LXIV, showing the hourly rate of change of temperature, is based upon Table LXI, and the changes are shown graphically in Fig. 25.

departures indicate the occurrence of the mean hourly temperature, and the greatest positive and negative departures, the maximum and minimum, respectively. The same change in time from month to month is apparent here as in Tables LXI and LXII.

4. *Mean hourly change in temperature.*—The change in mean temperature from day to day throughout the year (p. 30) is somewhat similar to the progress from hour to hour in the various months. Table LXIV is based upon Table LXI, and the rate of change is shown graphically in Fig. 25. The rate of increase is most rapid in about 3 hours after sunrise and continues so for a space of from 2 to 3 hours, while the rate of fall is much more gradual, exceeding 1° per hour only once in the early evening during the period from

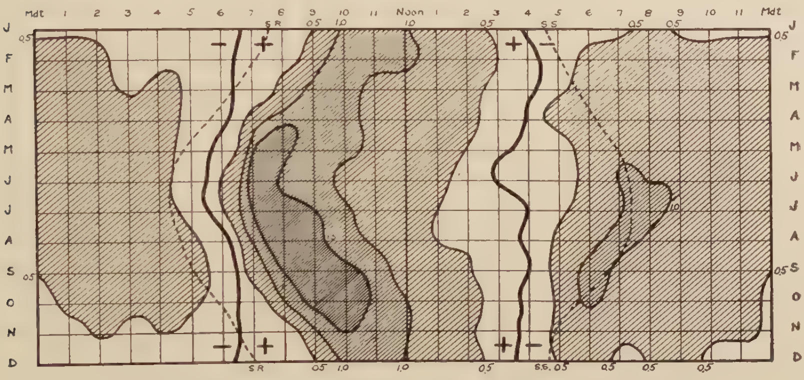


FIG. 25.—Mean hourly change of temperature, 1890–1910.

June to October, inclusive. The greatest rate of fall occurs generally between 7 and 8 P.M., except in the months of September and October, when it is about an hour earlier. The data in the table are, of course, average values, and individual cases are affected by the occurrence of warm periods, cold waves, sunshine, and storm; so that, as is the case with all figures involving means, the changes shown cannot ordinarily be expected for any one particular day. Yet they afford a valuable basis in the comparison of the average day in one season with that of another.

ILLUSTRATIONS OF SECONDARY CONTROLS OF TEMPERATURE

From the energy of the sun is received all but an infinitesimal portion of the heat necessary to our existence. His shifting northward and southward with the revolution of the earth brings the

change of seasons, while the rotation of the planet upon its axis compels the diurnal swing of temperature from the cool of the morning to the heat of the afternoon. These are the primary factors which govern the course of temperature year in and year out, but in every locality there are secondary controls which exercise a greater or lesser influence upon the actual conditions of any particular time. Among these at Chicago the most important are the winds of spring and summer as distinguished between land and lake breezes; the winds throughout the year as distinguished by their different directions; the hot wave and cold wave areas which approach generally from the southwest and the northwest, respectively; and the conditions of cloudiness and precipitation. Certain of these factors or their effects have already been described at some length (pp. 37, 72, 76), but further illustration of their action in this connection will prove interesting.

1. *Effect of lake and land winds.*—The influence of the shift of the wind from land to lake and from lake to land in spring and summer is shown forcibly in Figs. 26 and 27, containing the temperature curves of days on which such winds were the potent factors of control. In the first of the two figures is shown the curve for July 21, 1901, which has previously been cited as the day of the highest maximum temperature on record at Chicago, 103°, during the prevalence of one of the severest hot waves that the interior of the country has experienced. Until 2 P.M. the wind was a land breeze from the southwest, under the influence of which the temperature rose steadily to 102°. At that time, however, the wind shifted suddenly through north to northeast, with a velocity of about 15 miles an hour, and the resulting importation of cool air from the lake brought the temperature down from 102° to 84° in the space of a single hour. By 3 o'clock the wind had diminished greatly in velocity and shifted still farther to easterly, becoming southeast by 3:10 and south by 3:25 P.M., when it was again a land breeze and began to freshen. The action of a very light lake wind in lowering the temperature is weak (p. 44), and the mercury began to climb again soon after the shift to easterly, and as the direction became southwest by 6 P.M., rose to a point higher by 1° than before. The fall after 6 o'clock was simply the diurnal change.

Fig. 27 gives two instances of temperature curves of two days' length each on which the effect of lake and land winds is well marked, the temperature responding closely to the change in wind direction.

On May 24, 1904, shown in the upper portion of the figure, the temperature rose until 9 A.M., when it was 63°, the wind being light and therefore of little consequence. With an increase in velocity, however, and its shifting from southeast to east and northeast, the temperature fell considerably until about 5 P.M., reaching 49° at that hour, when the wind veered to southerly, and notwithstanding the diurnal influence it rose steadily until after 10 P.M. During the

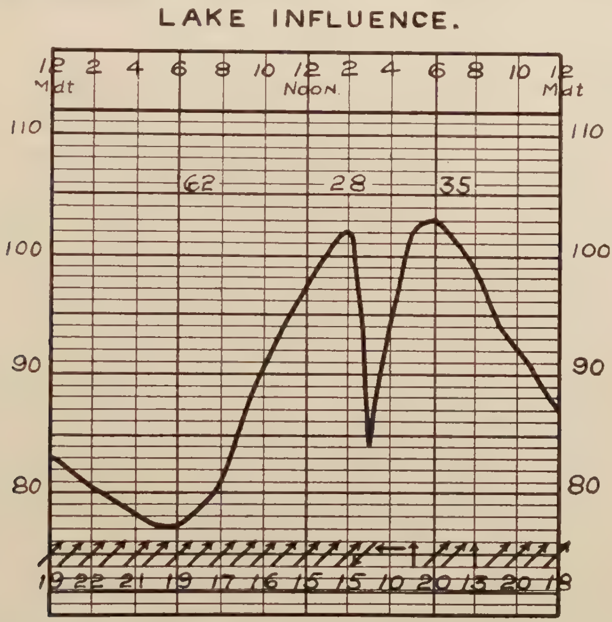


FIG. 26.—Temperature fall in hot wave during shift of wind to lake, July 21, 1901.

Fig. 26 shows the effect of a lake and land wind on temperature on a warm day, July 21, 1901. The upper figures show humidity; the lower figures show wind movement. The heavy line indicates temperature curve; the arrows show wind direction.

remainder of the night the temperature fell only 2°, reaching the minimum at 6 A.M. of the 25th. Thereafter, under the steady southwest wind it rose to a maximum of 87° at 3 P.M., the fall after that hour being the regular diurnal change.

The curve of April 20 and 21, 1907, illustrates the action of a steady lake wind in maintaining a fairly even temperature during the daytime. As a result, in this instance there was a range of only 5° throughout the entire 24 hours. The wind shifted to southwest

during the night, however, and on the 21st the temperature rose continuously, reaching its maximum, 57°, at about 4 P.M., and giving a range of 24° for the day. The conditions of sunshine and cloud were

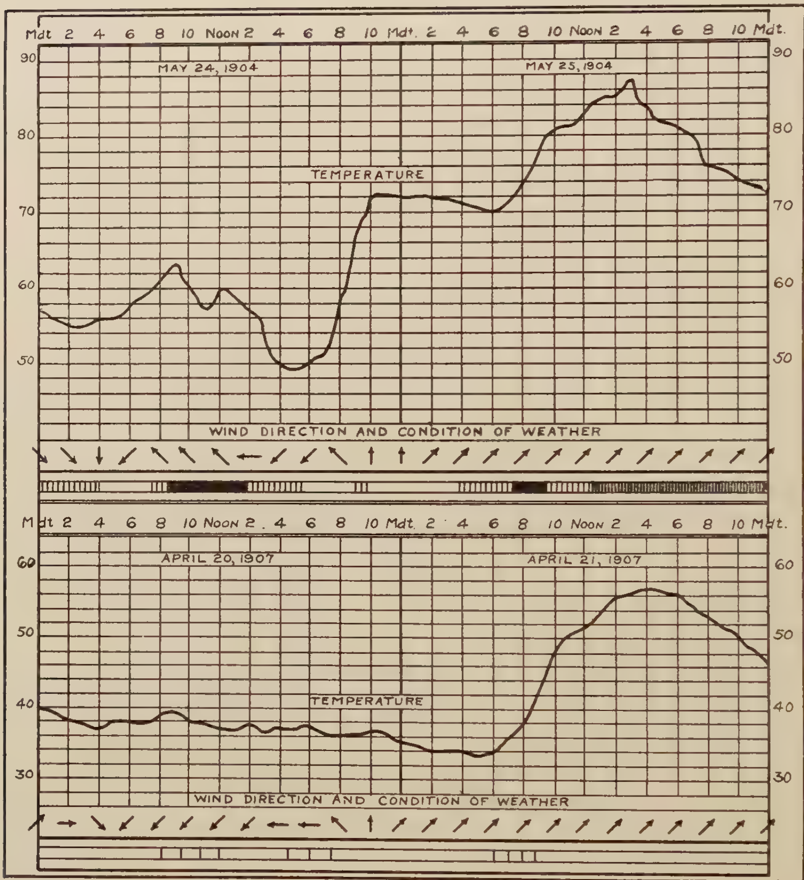


FIG. 27.—Effect of land and lake winds.

Fig. 27 shows the effect of land and lake winds on the temperature on selected days, May 24–25, 1904, and April 20–21, 1907. The arrows indicate the wind direction. Below the wind direction in each case is given the state of the weather. Where the space is filled in, rainy weather is indicated; and this varies through cloudy and partly cloudy to clear weather, where the space is left free.

practically the same on both days, so that the effect of the lake and land breezes is brought out clearly. The character of the weather is shown in both graphs directly under the arrows of wind direction, as

follows: black line, rain; heavily shaded strip, cloudy; lightly shaded strip, partly cloudy; clear strip, clear sky.

The direction of the wind is ordinarily regulated by the distribution of atmospheric pressure, the air moving in a general course from the region of high pressure to that of low pressure. An easterly wind therefore prevails at Chicago when the barometer is high over the lakes and low directly to the west or southwest. There are, however, other times in this locality when lake winds occur under different conditions of pressure, and blow during a portion of the day, changing to land winds at night, in a manner quite similar to the land and sea breezes of our coasts. Such is likely to be the case when the pressure varies but slightly over a large surrounding region, and the resulting winds are consequently light. It never occurs if the pressure conditions are such as to produce strong land winds during the night. During a day of lake and land breezes, as on July 21, 1901, described above, the isobaric surfaces, or planes of equal air pressure, are depressed by the contraction of the cooling air over the waters of the lake. The land being much warmer, the opposite is the case, and the isobaric surfaces over the land are bulged up, as it were, by the heated and expanding air. This is a gravitational effect that expresses itself first of all in the convective upward current over the land, disarranging the isobaric surfaces and resulting in an overflow of the upper air from land to lake down the now inclined surfaces, increasing the pressure there and forcing a lower return current from lake to land. The exchange continues until an equilibrium of pressure is re-established by the cooling of the air over the land; and in the evening or at night, when its temperature has fallen below that of the air over the lake, the pressure conditions of the day are reversed and the land wind sets in. This is the cause of the lake breeze, to which Chicago is indebted for its equable summer temperatures.

2. *Temperatures of cold days.*—Fig. 28 shows the variation in hourly temperature during two cold days, February 8 and 9, 1899, the minimum on the second day being $-21°$ and the maximum only $-8°$. The wind direction and velocity, and the pressure curve as well, are given, but the main purpose of the graph is to show the hourly variation of temperature during a severe cold wave. The cold was ushered in by brisk west and northwest winds on February 8, and the movement continued brisk through the following day.

3. *General effect of wind direction on temperature.*—We have already instanced the effect of certain winds upon the temperature

at Chicago. In individual cases, however, other influences are likely to be at work, so that the result looked for may not always be easy to perceive. If the average of a large number of cases is taken, in which the factor under study is present, the effect of other disturbing influences will be minimized. In endeavoring to determine the effect of general wind direction upon temperature, the hourly temperatures for the days upon which certain winds prevailed in the period from 1902 to 1908, inclusive, have been averaged, and the results are shown in Fig. 29, the months of January, April, July, and October being chosen as representatives of the different seasons.

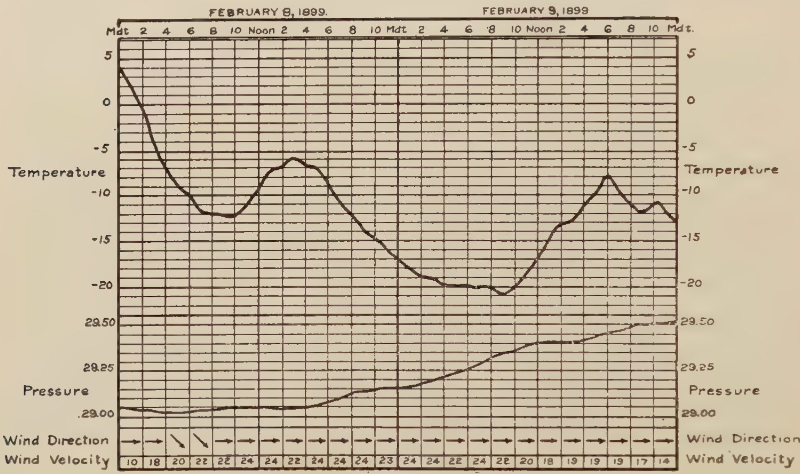


FIG. 28.—Examples of cold days.

Fig. 28 shows the temperature by hours during two cold days, February 8–9, 1899; also the barometer trace, and the wind direction and velocity at each hour.

Naturally, in all months the lowest temperatures occur with northerly winds, and the highest with southerly winds. The variation, however, is not nearly so marked in January as it is in April, and in this month the influence of the lake wind in reducing the diurnal range in temperature is plainly to be seen. It will be noted also that the variance for the different directions in the graphs is uniformly least at the time of daily minimum temperature, and greatest at the time of maximum.

4. *Effect of cloudiness and rainfall upon temperature.*—Fig. 30 has been prepared in a manner similar to that of the preceding graph, and for the same months and period of time. It will readily be seen

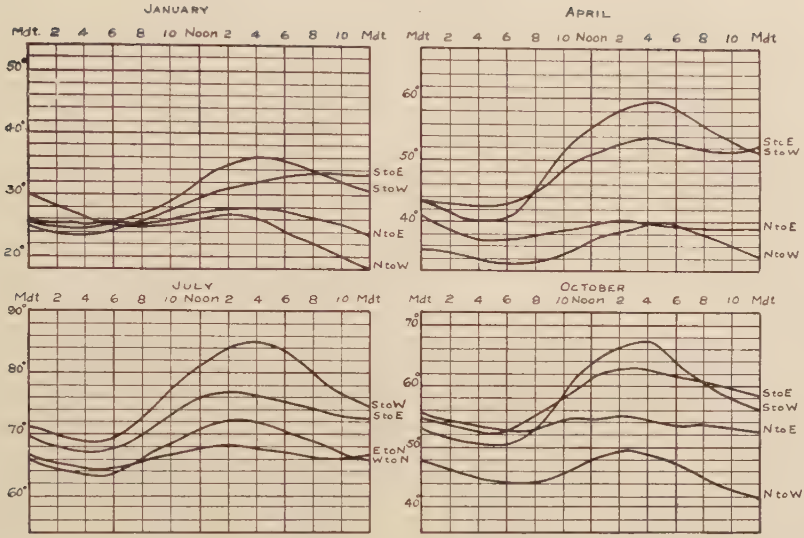


Fig. 29.—Effect of wind direction upon temperature.

Fig. 29 shows the effect of wind direction upon the temperature by hours for January, April, July, and October, based upon observations from 1902 to 1908.

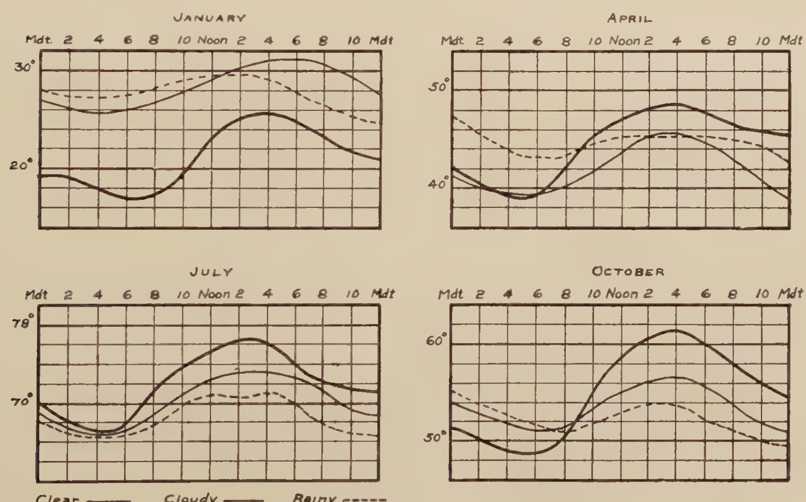


Fig. 30.—Effect of the character of the day on the temperature.

Fig. 30 shows the effect of the character of the weather upon the temperature by hours during January, April, July, and October, based upon observations from 1902 to 1908.

from the figure that the temperature fluctuates most on days of clear sky, because at such times the sun's rays during the daytime and the process of radiation at night have their greatest effectiveness. In the cold waves of winter, however, the weather is usually clear, and this accounts for the comparatively small amplitude in the month of January, although even then it is considerably greater than it is in cloudy and rainy weather. The greatest diurnal amplitude occurs in clear weather in the month of October, and in every case the least fluctuation is experienced during rainy days. In general, clear weather in July brings the highest temperatures, and this is also the case during the afternoon in April and October. In January, however, cold waves lower the temperature of clear days much below that on days of cloudiness and precipitation.

PART II

PRECIPITATION

PRECIPITATION

Precipitation, which includes rain, snow, sleet, hail, and appreciable amounts of deposited dew and fog, is measured in inches and fractions thereof in depth of fall. Rainfall and melted snowfall, sleet, and hail are measured in inches and hundredths; but snowfall, sleet, and hail are also measured unmelted when practicable, and the depths recorded in inches and tenths. Measureable amounts of fog and dew occur but rarely in Chicago, and are recorded in the same manner as is rainfall. Mean precipitation is the average of all the individual amounts occurring within the period in question, daily, monthly, or annual, as the case may be, covering the entire time of observation, and the term is applied to rainfall and snowfall separately and to all the forms of precipitation combined. The term "normal" (pp. 3–4) is used in the comparison of precipitation records in a way similar to that in which it was used in the comparison of temperature conditions.

There are no continuous records of precipitation for Chicago prior to 1867, when a series of observations was begun under the direction of the Smithsonian Institution, and continued until the date of the establishment of the local Weather Bureau office in 1870. Before the beginning of the Smithsonian Institution observations, however, records of a more or less intermittent character were being made at various places in northern Illinois, some of them overlapping one another, and being maintained through a portion of the period of official observations. These have been compared with the Chicago records by Professor Hazen in his *Climate of Chicago* (1893), in which he publishes, in the absence of official data, estimated precipitation for the city as far back as 1843, obtaining his figures by interpolation, as he did in the case of temperature (p. 4). Such records must, of course, lack much in exactness, because near-by stations often vary considerably in precipitation, especially in summer thunderstorm periods. The estimates, however, were most carefully made, and are the best data available on the subject. It should therefore be borne in mind, in the study of the records presented in this volume, that previous to the year 1867 the precipitation values are largely estimated, and that from 1867 to 1870, inclusive, they are the records of voluntary observers of the Smith-

sonian Institution, while since 1870 they are comprised in the official records of the Weather Bureau.

ANNUAL, SEASONAL, AND MONTHLY PRECIPITATION

Fig. 31 shows the annual amounts of precipitation for the entire period from 1843 to 1910, inclusive; Table LXV the annual and monthly, and Table LXVI the seasonal precipitation from 1843 to 1913. The mean annual precipitation to 1910 is 33.99 inches, but there is a great variation from year to year; while the mean as obtained from the official record beginning with 1871 is 33.52 inches. From the graph it can readily be seen that much of the deficiency which caused this falling off of 0.47 inch in the mean occurred between the years 1885 and 1905, and covers very

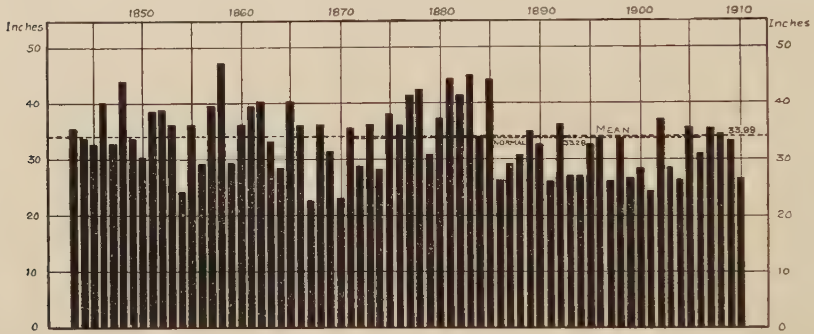


FIG. 31.—Variations in the annual amount of precipitation, 1843–1910.

nearly the time during which the Weather Bureau occupied quarters in the Chicago Opera House Block and the Auditorium Tower. The cause of this variation is believed to be due to the character of the exposure of the rain gage, as that at the latter location is known to have been somewhat unsuited to the purpose, and any changes in a city exposure are sure to affect the resulting record. The year of greatest precipitation for the entire time occurred in the period of the old records, 47.10 inches in 1858. The highest annual average for any decade, however, was entirely within the official period, 36.48 inches from 1881 to 1890; and this is true also of the wettest 5-year period, which covered the first half of this decade, and averaged 42.07 inches annually. Three years of the period last named approached the record of 1858: 1881 with 44.18 inches; 1883 with 45.86 inches, the largest annual amount of the official period; and

TABLE LXV

MONTHLY AND ANNUAL PRECIPITATION, INCHES, 1843–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Normal, 1871–1906	2.00	2.16	2.55	2.88	3.37	3.66	3.64	2.88	3.02	2.55	2.50	2.07	33.28
1843	2.0	1.9	3.0	4.5	4.0	4.6	1.4	2.4	3.0	1.2	5.1	2.4	35.50
1844	2.8	1.3	1.76	2.76	6.0	5.5	5.0	4.2	0.8	1.6	0.7	0.7	33.12
1845	2.0	0.5	2.2	6.5	2.0	3.8	3.5	1.2	4.4	1.4	3.3	1.5	32.30
1846	4.9	1.8	2.6	7.8	2.4	4.3	2.9	1.0	5.0	0.8	1.5	5.0	40.00
1847	2.3	3.5	1.5	2.1	3.3	1.5	2.8	2.0	3.2	4.6	4.8	1.2	32.80
1848	1.6	2.4	4.5	3.3	3.8	4.4	3.4	5.1	2.2	3.2	2.1	8.4	44.40
1849	5.5	1.0	4.7	1.8	3.8	3.6	2.3	3.5	2.6	2.8	1.4	1.2	34.20
1850	2.1	0.7	2.0	3.8	1.9	3.1	2.1	6.4	1.4	2.0	3.2	1.7	30.40
1851	1.5	3.8	0.8	4.2	6.7	5.3	3.8	3.1	3.2	2.3	2.3	1.6	38.60
1852	2.0	1.2	5.5	4.8	2.4	2.5	3.4	0.6	2.3	6.8	4.0	3.3	38.80
1853	1.4	2.2	1.8	2.8	4.4	4.9	6.1	2.2	4.2	2.0	2.1	2.3	36.40
1854	1.3	1.9	2.1	2.1	3.1	2.6	3.0	0.9	1.6	3.6	1.0	1.4	24.60
1855	8.0	0.6	2.6	1.4	2.5	3.7	5.8	3.2	2.3	2.0	2.2	2.0	36.30
1856	0.9	1.8	0.6	2.6	4.8	2.5	2.1	1.3	2.5	2.1	3.98	3.86	29.04
1857	1.09	5.43	2.55	2.19	6.33	4.14	3.0	5.0	2.2	4.0	2.7	1.2	39.83
1858	1.3	1.4	3.0	3.1	7.8	6.3	5.9	3.2	4.0	4.6	4.5	2.0	47.10
1859	1.4	1.8	5.2	3.4	3.6	1.7	0.9	0.4	2.2	4.1	2.8	1.8	29.30
1860	1.6	1.6	1.0	2.8	4.6	3.5	5.3	2.6	2.8	4.1	2.3	4.2	36.40
1861	1.4	3.0	3.4	4.7	3.7	2.1	4.3	2.4	3.4	7.5	1.5	1.9	39.30
1862	4.0	0.7	2.0	5.2	4.3	2.9	6.7	3.6	5.6	2.92	1.2	1.3	40.42
1863	2.8	2.6	2.1	2.1	5.1	1.3	2.3	4.2	1.6	4.0	1.9	3.6	33.60
1864	1.6	0.4	2.1	3.2	1.9	2.1	6.4	1.1	2.1	1.9	3.1	2.5	28.40
1865	0.4	3.1	3.1	3.8	1.5	5.1	6.1	7.2	4.8	4.0	0.5	0.6	40.20
1866	2.8	1.6	2.2	2.8	2.0	4.4	4.7	4.2	4.6	2.8	0.8	3.4	36.30
1867	1.93	2.22	1.58	1.70	4.42	1.86	1.52	2.33	0.57	1.28	1.89	1.11	22.41
1868	1.28	0.92	5.24	3.00	3.74	3.11	2.87	3.55	7.08	1.69	2.60	1.40	36.48
1869	1.97	2.23	1.33	4.30	5.69	5.03	3.26	1.32	0.89	1.10	2.42	2.03	31.57
1870	1.95	0.86	1.81	1.15	0.80	1.70	3.71	2.07	2.82	2.43	1.16	2.46	22.92
1871	4.13	1.45	2.66	3.70	3.90	5.56	2.52	2.01	0.74	1.88	3.62	3.44	35.61
1872	0.68	0.84	3.79	3.03	3.24	3.45	3.09	2.59	6.43	0.65	1.06	0.22	29.07
1873	2.56	0.47	0.89	6.22	7.20	1.44	4.04	1.58	3.53	2.43	1.61	4.44	36.41
1874	3.47	1.51	2.15	2.67	2.08	3.25	0.58	3.15	3.76	2.55	2.83	0.63	28.63
1875	0.96	1.99	1.43	2.32	3.64	5.17	7.18	3.29	4.39	4.32	0.75	2.62	38.06
1876	3.22	3.90	4.04	2.07	1.85	5.96	3.11	3.66	3.74	1.20	3.25	0.48	36.48
1877	1.91	0.06	5.37	2.42	1.81	6.04	2.98	3.06	2.02	6.51	6.08	2.75	41.01
1878	1.31	2.12	4.39	5.57	5.22	3.02	6.09	3.66	1.99	5.17	0.83	2.58	41.95
1879	0.54	1.47	2.37	1.93	3.89	3.18	5.58	0.45	1.18	2.72	4.93	2.47	30.71
1880	3.53	2.91	2.25	5.20	4.97	3.50	3.07	4.47	2.25	3.19	0.87	1.11	37.32
1881	0.87	5.98	2.99	1.84	1.85	5.93	4.31	0.54	4.34	6.89	5.97	2.67	44.18
1882	1.55	2.24	3.43	6.72	5.52	5.71	3.43	4.96	0.91	3.40	1.48	1.99	41.34
1883	1.74	4.74	0.42	3.72	7.32	5.61	5.53	1.21	1.36	7.36	5.26	1.59	45.86
1884	1.39	3.27	5.16	3.05	1.53	2.11	3.71	2.50	2.29	3.59	1.80	4.21	34.61
1885	3.18	2.01	0.57	4.00	3.17	5.20	2.44	11.28	2.97	3.87	2.33	3.35	44.37
1886	3.56	1.51	1.79	1.29	1.00	0.94	1.53	3.38	6.93	1.42	1.66	1.76	26.77
1887	3.13	5.10	0.89	0.46	1.38	1.63	1.05	3.35	4.03	2.03	2.41	3.67	29.13
1888	1.56	1.51	2.99	2.13	6.22	1.66	3.93	2.10	0.98	2.95	2.89	1.94	30.86
1889	1.64	1.31	1.43	2.35	5.38	2.93	9.56	0.39	2.75	1.82	3.49	1.90	34.95
1890	2.98	2.47	2.10	3.23	5.13	3.25	2.57	2.58	1.39	4.20	1.59	1.25	32.69
1891	1.99	1.95	2.13	3.14	2.09	2.42	2.47	4.52	0.32	0.36	3.83	1.32	26.54
1892	1.99	1.57	2.21	2.17	6.77	10.58	2.23	1.85	1.34	1.54	2.68	1.63	36.56
1893	2.08	2.44	1.69	4.16	1.93	3.59	3.08	0.18	1.98	1.75	2.45	2.14	27.47
1894	1.55	2.13	2.66	2.65	3.35	1.96	0.60	0.60	8.28	0.84	1.18	1.66	27.46
1895	2.15	1.60	1.32	0.86	1.99	1.79	2.42	6.49	0.89	0.51	5.60	6.76	32.38
1896	1.12	3.48	1.26	2.79	4.16	2.82	3.61	3.52	6.70	1.36	2.16	0.16	33.14
1897	4.53	2.22	3.56	2.23	0.84	3.60	1.47	1.70	0.84	0.18	3.06	1.62	25.85
1898	3.54	2.59	4.60	0.76	2.23	5.30	1.94	3.03	3.16	3.26	2.25	1.11	33.77
1899	0.58	1.60	2.11	0.14	4.35	2.71	6.66	0.91	2.39	2.09	1.14	1.81	26.49
1900	1.21	3.52	1.58	1.02	3.59	2.06	4.64	4.24	1.56	1.35	3.30	0.58	28.65
1901	1.15	2.05	3.38	0.33	2.18	2.42	4.25	2.00	2.92	1.29	0.85	1.70	24.52
1902	0.66	1.53	4.16	2.26	5.08	6.45	5.78	1.44	4.83	1.45	2.03	1.90	37.57
1903	1.09	3.03	1.67	3.77	0.93	1.62	4.78	3.49	4.00	1.09	0.34	2.28	28.09
1904	2.25	1.71	4.57	3.01	1.54	0.55	2.76	4.00	2.65	1.58	0.31	1.21	26.14
1905	1.33	1.95	2.43	3.03	5.14	3.27	5.02	4.46	4.18	1.82	2.05	0.68	35.36
1906	1.67	2.37	1.61	1.86	2.09	1.87	4.84	1.43	5.54	2.05	3.08	2.46	30.87
1907	4.21	1.00	2.94	2.37	3.50	3.64	3.15	4.22	4.49	0.93	1.92	2.73	35.10
1908	2.05	3.72	3.48	2.81	6.74	1.48	1.45	6.35	2.09	0.81	2.67	1.18	34.83
1909	1.96	3.84	1.63	7.73	2.18	5.09	1.77	6.20	3.60	1.20	3.84	4.18	43.22
1910	3.07	0.89	0.29	3.84	4.67	0.91	1.79	3.08	3.90	1.79	1.31	1.32	26.86
1911*	1.17	2.27	1.45	3.03	3.37	2.54	2.65	3.72	4.03	3.79	3.27	2.54	33.83
1912*	0.84	1.57	2.20	2.55	3.97	1.78	3.86	3.59	3.26	3.52	1.45	1.08	29.67
1913*	1.33	1.97	3.44	1.91	4.38	1.08	3.30	4.06	1.49	2.23	1.47	0.45	27.11

* Not included in means.

TABLE LXV—*Continued*

Mean Precipitation by Decades, Inches

Decades	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1843–50	2.90	1.64	2.78	4.07	3.40	3.85	2.92	3.22	2.82	2.20	2.76	2.76	35.35
1851–60	2.05	2.17	2.46	2.94	4.62	3.71	3.93	2.25	2.73	3.56	2.79	2.36	35.64
1861–70	2.01	1.76	2.49	3.20	3.32	2.96	4.19	3.20	3.35	2.96	1.71	2.03	33.16
1871–80	2.23	1.67	2.93	3.51	3.78	4.26	3.82	2.79	3.00	3.06	2.58	2.07	35.52
1881–90	2.16	3.01	2.18	2.88	3.85	3.50	3.81	3.23	2.80	3.75	2.89	2.43	36.48
1891–1900	2.07	2.31	2.31	1.99	3.13	3.68	2.91	2.70	2.75	1.32	2.76	1.88	29.83
1901–10	1.94	2.21	2.62	3.10	3.40	2.73	3.56	3.67	3.82	1.40	1.84	1.96	32.26
Mean 1871–1910	2.10	2.30	2.51	2.87	3.54	3.49	3.53	3.10	3.09	2.38	2.52	2.09	33.52
Mean 1843–1910	2.18	2.13	2.53	3.07	3.65	3.52	3.61	3.00	3.04	2.62	2.47	2.20	33.99
1871–1913 Greatest	4.53	5.98	5.37	7.73	7.32	10.58	9.56	11.28	8.28	7.36	6.08	6.76	44.37
1871–1913 Year	1897	1881	1877	1909	1883	1892	1889	1885	1894	1883	1877	1895	1885
1871–1913 Least	0.54	0.06	0.29	0.14	0.84	0.55	0.58	0.18	0.32	0.18	0.31	0.16	24.52
1871–1913 Year	1879	1877	1910	1899	1897	1904	1874	1893	1891	1897	1904	1896	1901

Table LXV shows the total monthly and annual precipitation for Chicago for the years from 1843 to 1913. Prior to 1867 measurements of precipitation were intermittent, and the amounts not actually observed (given to tenths in the table) were interpolated from the records of adjoining stations. From 1867 to 1871 the measurements were taken by voluntary observers reporting to the Smithsonian Institution. From 1871 to 1913 the observations have been taken by the United States Weather Bureau. The means of the monthly and annual amounts from 1871 to 1906 have been adopted as the monthly and annual normals, appearing at the top of the table.

1885 with 44.37 inches. The least yearly precipitation on record also occurred in the old period, 22.41 inches in 1867, while the least amount in the official period was 24.52 inches in 1901. Years with less than 30 inches, however, were very few prior to 1886, and but three such years have occurred since the removal of the Weather Bureau office to the Federal Building in 1905. Between these dates, out of 19 years, 11 show less than 30 inches, but, as indicated above, the record is thought to have been affected by the poor exposures of the rain gage.

Taking the precipitation by seasons from 1843, the greatest amount in winter, as indicated in Table LXVI, is 14.90 inches in 1848–49, while the next greatest amount occurred in 1895–96, 11.36 inches. In spring, the greatest amount is 15.67 inches, in 1882. In summer, the greatest amount is 18.92 inches, in 1885; and in autumn, 17.20 inches, in 1881. The least amount in winter is 2.45 inches, in 1876–77; in spring, 2.73 inches, in 1887; in summer, 3.00 inches, in 1859, old record, and 3.16 inches, in 1894, new record; in autumn, 3.10 inches, in 1844, old record, and 4.08 inches, in 1897, new record. By seasons the means of the official period increase from a winter minimum of 6.48 inches, through spring with an average of 8.92 inches, to a summer maximum of 10.12 inches, falling off thereafter to an autumn mean of 8.00 inches. For the entire

period of record from 1843, the seasonal means are slightly higher than these, with the exception of that of summer, which is practically the same as that of the official reading.

The same variation in seasonal amounts can be noted in the table as was seen to be the case with the annual values, and there are a number of marked instances in all of the seasons in which the

TABLE LXVI

Total Seasonal Precipitation, Inches, 1843–1913

(See explanation under Table LXV)

Year	Winter	Spring	Summer	Autumn	Year	Winter	Spring	Summer	Autumn
1843	....	11.5	8.4	9.3	1883–84	6.25	9.74	8.32	7.68
1843–44	6.5	10.52	14.7	3.1	1884–85	9.40	7.74	18.92	9.17
1844–45	3.2	10.7	8.5	9.1	1885–86	8.42	4.08	5.85	10.01
1845–46	8.2	12.8	8.2	7.3	1886–87	9.99	2.73	6.03	8.47
1846–47	10.8	6.9	6.3	12.6	1887–88	6.74	11.34	7.69	6.82
1847–48	5.2	11.6	12.9	7.5	1888–89	4.89	9.16	12.88	8.06
1848–49	14.9	10.3	9.4	6.8	1889–90	7.35	10.46	8.40	7.18
1849–50	4.0	7.7	11.6	6.6	1890–91	5.19	7.36	9.41	4.51
1850–51	7.0	11.7	12.2	7.8	1891–92	4.88	11.15	14.66	5.56
1851–52	4.8	12.7	6.5	13.1	1892–93	6.15	7.78	6.85	6.18
1852–53	6.9	9.0	13.2	8.3	1893–94	5.82	8.66	3.16	10.30
1853–54	5.5	7.3	6.5	6.2	1894–95	5.41	4.17	10.70	7.00
1854–55	10.0	6.5	12.7	6.5	1895–96	11.36	8.21	9.95	10.22
1855–56	4.7	8.0	5.9	8.58	1896–97	6.91	6.63	6.77	4.08
1856–57	10.38	11.07	12.14	8.9	1897–98	7.75	7.59	10.27	8.67
1857–58	3.9	13.9	15.4	13.1	1898–99	3.29	6.60	10.28	5.62
1858–59	5.2	12.2	3.0	9.1	1899–1900	6.54	6.19	10.94	6.21
1859–60	5.0	8.4	11.4	9.2	1900–1901	3.78	5.89	8.67	5.06
1860–61	8.6	11.8	8.8	12.4	1901–2	3.89	11.50	13.67	8.31
1861–62	6.6	11.5	13.2	9.72	1902–3	6.02	6.37	9.89	5.43
1862–63	6.7	9.3	7.8	7.5	1903–4	6.24	9.12	7.31	4.54
1863–64	5.6	7.2	9.6	7.1	1904–5	4.49	10.60	12.75	8.05
1864–65	6.0	8.4	18.4	9.3	1905–6	4.72	5.56	8.14	10.67
1865–66	5.0	7.0	13.3	8.2	1906–7	7.67	8.81	11.01	7.34
1866–67	7.55	7.70	5.71	3.74	1907–8	8.50	13.03	9.28	5.57
1867–68	3.31	11.98	9.53	11.37	1908–9	6.98	11.54	13.06	8.64
1868–69	5.60	11.32	9.61	4.41	1909–10	8.14	8.80	5.78	7.00
1869–70	4.84	3.76	7.48	6.41	1910–11*	4.76	7.85	8.91	11.09
1870–71	8.04	10.26	10.09	6.24	1911–12*	4.95	8.72	9.23	8.23
1871–72	4.96	10.06	9.13	8.14	1912–13*	4.38	9.73	8.44	5.19
1872–73	3.25	14.31	7.06	7.57					
1873–74	9.42	6.90	6.98	9.14	1843–1910				
1874–75	3.58	7.39	15.64	9.46	means	6.52	9.26	10.11	8.14
1875–76	9.74	7.96	12.73	8.19	1871–1910				
1876–77	2.45	9.60	12.08	14.61	means	6.48	8.92	10.12	8.00
1877–78	6.18	15.18	12.77	7.99					
1878–79	4.59	8.19	9.21	8.83	Greatest	14.9	15.67	18.92	17.20
1879–80	8.91	12.42	11.04	6.31	Year	1848–49	1882	1885	1881
1880–81	7.96	6.68	10.78	17.20	Least	2.45	2.73	3.0	3.1
1881–82	6.46	15.67	14.10	5.79	Year	1876–77	1887	1859	1844
1882–83	8.47	11.46	12.35	13.98					

* Not included in means.

precipitation was much above or below the normal. These seasons are given in Tables LXVII and LXVIII. The summers of 1865 and 1885 were very wet, having almost twice the normal amount of rainfall for the season; while those of 1859 and 1894 were of quite the opposite character, averaging only about 1 inch for each month of the time. In only two cases, however, has more than twice the normal

amount of precipitation actually occurred in a season, the winter of 1848–49 with 14.9 inches, exceeding its normal by 8.67 inches, and the autumn of 1881 with 17.20 inches, exceeding its normal by 9.13 inches. On the other hand, the winter of 1844–45, the summers of 1859 and 1894, and the autumns of 1844 and 1867 all received approximately one-half, or less, of their normal amounts.

TABLE LXVII

SEASONS WITH EXCESSIVE PRECIPITATION

Winter Normal 6.23		Spring Normal 8.80		Summer Normal 10.18		Autumn Normal 8.07	
1846–47	+4.57	1858	+5.10	1844	+4.52	1847	+4.53
1848–49	+8.67	1873	+5.51	1858	+5.22	1852	+5.03
1856–57	+4.15	1878	+6.38	1865	+8.22	1858	+5.03
1895–96	+5.13	1882	+6.87	1875	+5.46	1861	+4.33
		1908	+4.23	1885	+8.74	1877	+6.54
				1892	+4.48	1881	+9.13
						1883	+5.91

Table LXVII contains a list of seasons with an excess in precipitation of 4.00 inches and over, 1843–1913.

TABLE LXVIII

SEASONS WITH DEFICIENT PRECIPITATION

Winter Normal 6.23		Spring Normal 8.80		Summer Normal 10.18		Autumn Normal 8.07	
1844–45	−3.03	1870	−5.04	1847	−3.88	1844	−4.97
1876–77	−3.78	1886	−4.72	1852	−3.68	1867	−4.33
		1887	−6.07	1854	−3.68	1869	−3.66
		1895	−4.63	1856	−4.28	1891	−3.56
				1859	−7.18	1897	−3.99
				1867	−4.47	1901	−3.01
				1873	−3.12	1904	−3.53
				1874	−3.20		
				1886	−4.33		
				1887	−4.15		
				1893	−3.33		
				1894	−7.02		
				1897	−3.41		
				1910	−4.40		

Table LXVIII contains a list of seasons with a deficiency in precipitation of 3.00 inches and over, 1843–1913.

In Plate VIII are given the departures of monthly, seasonal, and annual precipitation from the normal, from 1843 to 1910. The figures show clearly the great irregularity in the amounts of precipitation from month to month, and from year to year, and yet the average annual falls for the decades of the period, shown in Table LXV, differ but little, and would doubtless differ still less were the entire record obtained from a gage exposed in the same location and with the same surroundings. There is a tendency for the annual

precipitation to average up in the long run, as is shown in the plate by the departure line crossing and recrossing the normal precipitation line. The period from 1875 to 1885 was apparently one of abnormally heavy precipitation, and the period from 1893 to 1904 one of more than ordinary dryness. Taking the plate as a whole, however, there is little or no uniformity in the annual, seasonal, or monthly variations.

The statements made (p. 23) relative to uniformity in the succession of years and seasons with regard to temperature, may appropriately be applied also in the case of precipitation. A careful study of Tables LXV, LXVI, LXVII, and LXVIII, and Plate VIII shows clearly that in no instance does the precipitation of any year or season afford a clue to that of any succeeding year or season. Instances are apparent of several years together with extraordinary precipitation, such as 1880–83, and there are times of deficient precipitation for several years, as 1899–1901; but these intervals do not appear to recur with any regularity. Again, some very wet years have been followed by years of deficient rainfall, as in 1885 (44.37 inches) and 1886 (26.77 inches). The reverse is also true, as in 1874 (28.63 inches) and 1875 (38.06 inches). Both wet and dry years have been followed by years of normal precipitation, and vice versa, and in none of the instances does there appear to be regularity of succession. The same is true also of the seasons.

From the means given at the bottom of the table of monthly values, shown graphically in Fig. 32, for the official period, it will be seen that the average monthly amounts of precipitation increase gradually from the winter season to May, then remain nearly the same until the end of July, decreasing irregularly thereafter until November. August and September have about the same average rainfall, and the fall of December about equals that of January. It is apparent that the greatest amount of precipitation throughout the year is received during the growing season, when moisture is most needed; but at all times there is, on the average, a sufficient fall, so that there is no division in the nature of a wet and dry season.

There is a great difference between the highest and lowest precipitation records for the various months of the year. The comparison is shown in Fig. 33, in which the line of mean precipitation is also drawn for the purpose of indicating the excesses and deficiencies, as well. The variation is much more pronounced in the summer

season, but even in the winter months there is a difference of from 4 to 6 inches between the greatest and least values. The exact amounts for the months of extreme record, and the year in which each occurred, are shown at the bottom of Table LXV, the greatest monthly amount being 11.28 inches in August, 1885, and the least, 0.06 inch in February, 1877. It will be seen that in no instance do any two successive months in one year hold the record of highest

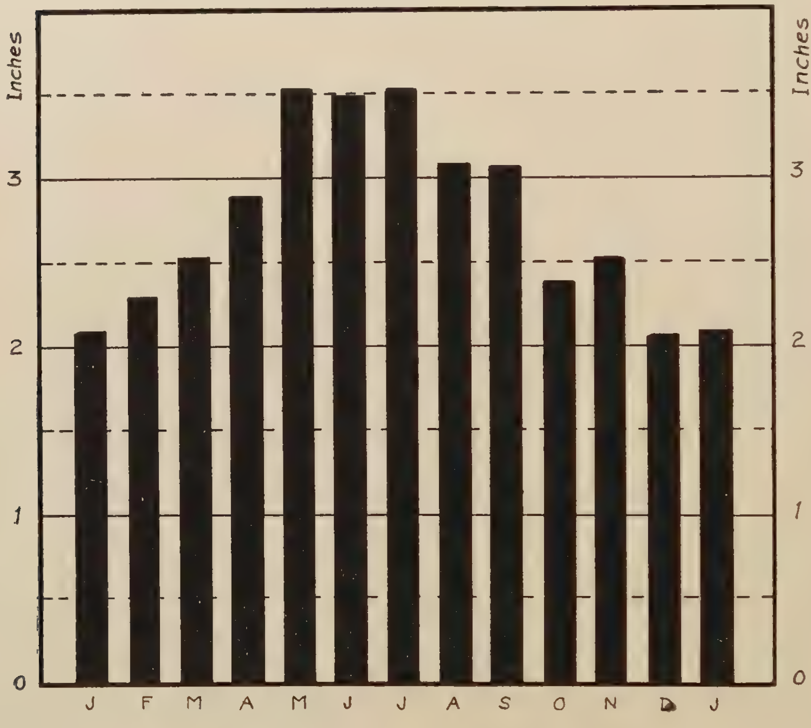


Fig. 32.—Mean monthly precipitation, 1871–1910.

or lowest precipitation, nor does the same month show the extremes in any two successive years. The record for greatest precipitation for March and November is in 1877, for May and October is in 1883; the record for least precipitation for May and October is in 1897, which was deficient in total amount by 7.43 inches, and that for June and November is in 1904. In no other cases does the same year appear twice in the record of either extreme.

Even in years of pronounced character, dry or wet, there is considerable variation from month to month, although usually

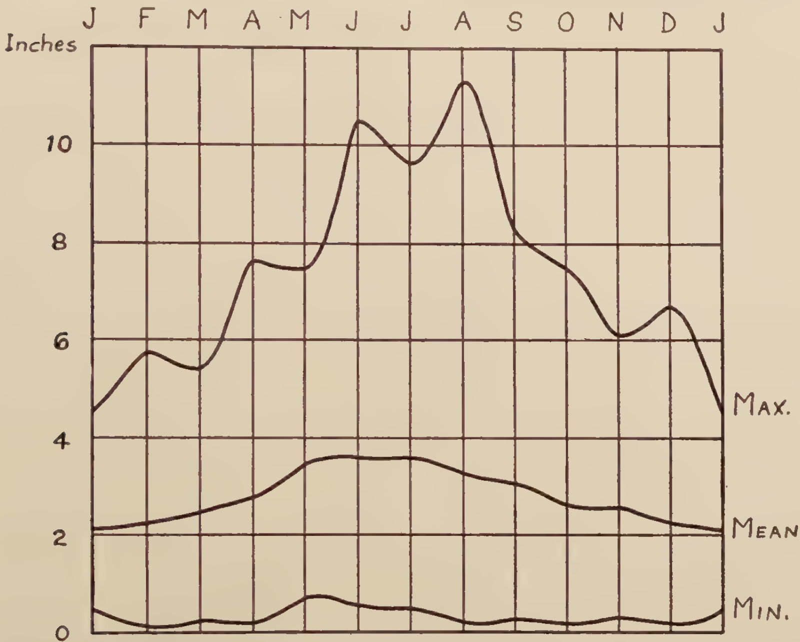


FIG. 33.—Monthly amount of precipitation, 1871–1910.

FIG. 34.—Total monthly precipitation during a dry year, a normal year, and a wet year, the curved solid line in each case representing the monthly normals.

the majority of the months in such cases are of the same kind as the year itself. This variation is illustrated in Fig. 34, which gives

the monthly precipitation for each of the years 1867, 1896, and 1858. The second of these was a year of very nearly normal precipitation, while the others were the record years for least and greatest amounts since 1843, having 22.41 inches, 33.14 inches and 47.10 inches, respectively. In 1867 the precipitation was below the normal in each month with the exception of February, which was just normal, and of May, which was considerably above. In 1896, the variation in monthly amount was very great, some months, especially at the beginning and at the end of the year, having much less than the normal amount, while others had much more. The month of December in that year, with a total of only 0.16 inch, holds the record for least December precipitation, while the fall in September, 6.70 inches, has been exceeded but twice in that month. Only two months, April and July, received rainfall in this year approximating closely to the respective monthly normals, and yet the total for the year differed from the annual normal by only 0.14 inch. In 1858 the first two months were below the normal, and May, June, July, September, October, and November considerably above. The amount in May, 7.80 inches, is the greatest precipitation in that month in either the old or the official records, while the amounts in June and July were also quite heavy.

INFLUENCE OF EXPOSURE IN MEASUREMENT OF PRECIPITATION

Reference has already been made to the effect of varying exposures of the rain gage upon the amount of precipitation registered (p. 152), and, unfortunately, the position of the official rain gage has been changed several times since the establishment of the Weather Bureau office. There are two periods of approximately 15 years each, when the office occupied the Major Block and the Auditorium Tower, and two much shorter periods, one at the Chicago Opera House Building and the present at the Federal Building. Experience and careful record have shown that, where suitable ground exposure is not to be had, the best position for the rain gage is on a large flat roof, as far from the edge and any projections or openings as possible. Such an exposure was that at the Major Block, and it was as good as could be secured in the business section of a large city. The present position of the rain gage on the north roof of the Federal Building is also well suited to the purpose, and it compares favorably with that at the Major Block. The character of the exposure at the Chicago Opera House Building, so far as the location of surrounding objects

likely to interfere with the fall of rain is concerned, is not apparent from the available records, but that on the top of the Auditorium Tower was most unsatisfactory. Here the gage was located upon the west parapet of the main tower, and near the inner edge. A short distance to the east within the parapet the smaller tower of the building extended upward for about 25 feet above the top of the gage. In such a place the catch of the instrument was much affected at times by swirls and eddies of wind which carried the rain or snow either upward or horizontally across the opening, and did not permit the whole amount to fall inside. Such swirls and eddies were there common to winds from all directions if the velocity was more than a few miles an hour; and as many of our heaviest rains and snows occur with winds of more than average velocity, it will readily be seen that the effect of the location was to reduce materially the catch of the gage.

The monthly and annual amounts for the periods of exposure at the various locations from 1873 to 1910 are shown in Table LXIX.

TABLE LXIX

MONTHLY AND ANNUAL PRECIPITATION AT FOUR EXPOSURES, INCHES

Exposure	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Major Block (4)	1.83	2.59	2.80	3.29	3.37	4.08	3.83	3.37	2.98	3.90	2.83	2.33	37.20
Chicago Opera House (3)	2.33	2.64	1.77	1.65	4.33	2.07	4.85	1.95	2.59	2.27	2.93	2.50	31.88
Auditorium Tower (2)	1.81	2.24	2.59	2.22	3.21	3.40	3.28	2.70	2.88	1.52	2.18	1.81	29.84
Federal Building (1)	2.59	2.36	1.99	3.72	3.84	2.60	3.00	4.29	3.97	1.43	2.48	2.09	34.36

Major Block, from June 8, 1873, to December 31, 1886, inclusive.

Chicago Opera House, from January 1, 1887, to January 31, 1890, inclusive.

Auditorium Tower, from February 1, 1890, to June 30, 1905, inclusive.

Federal Building, from July 1, 1905, to 1910.

Table LXIX contains the average monthly and annual precipitation for four exposures as given above, together with the length of time the Weather Bureau was located at each place. These values are graphically shown in Fig. 35 the figures "4," "3," etc., appearing after each location, refer to this figure.

Fig. 35 gives the same data, and the variations are brought out more clearly by the illustration. Special attention should be paid to the representation of the average annual precipitation at the right side of the figure. These records are for entirely different periods of time, nor are there any synchronous observations by which the falls at the various locations can be strictly compared with each other. Yet, while a casual inspection of the graph would seem to show that Chicago's precipitation has changed greatly in amount during the period of official record, a knowledge of the character of the exposures of the rain gages at the Major Block, the Auditorium Tower,

and the Federal Building leads to the opinion that such is not the case, but that the differences are due in most part to the influence of the surrounding objects and conditions. The record at the Chicago Opera House Building is too short to permit judgment in its particular case, the very large variation in the monthly amounts indicating this fact clearly, but the effect of the poor conditions at the Auditorium Tower cannot be questioned. It is not possible to

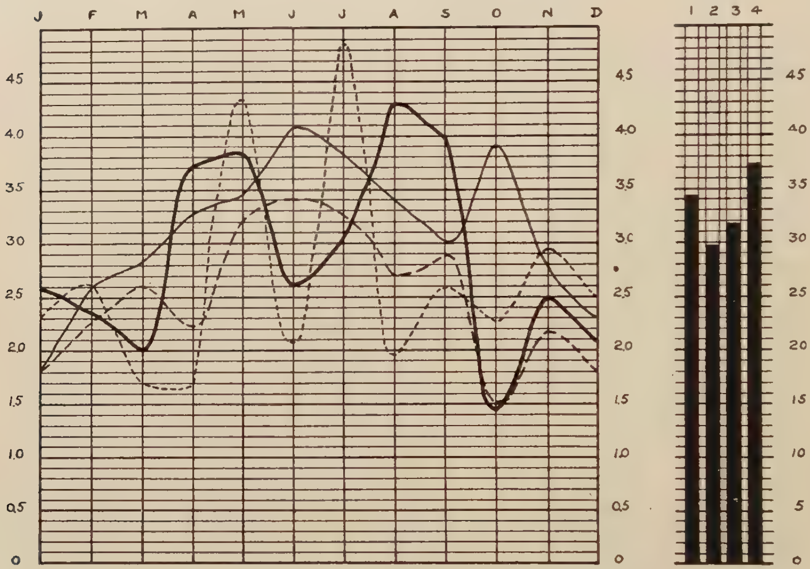


FIG. 35.—Monthly and annual precipitation in inches: four exposures (see Table LXIX).

1=Federal Building, elevation 133 ft., exposure July 1, 1905, to date, ———

2=Auditorium Tower, elevation 238 ft., exposure February 1, 1890, to June 30, 1905, inclusive, — — —

3=Chicago Opera House Building, elevation 132 ft., exposure January 1, 1887, to January 31, 1890, nclusive, - - - - -

4=Major Block, elevation 93 ft., exposure June 8, 1873, to December 31, 1886, inclusive, ———

determine the exact amount of this influence, however, as there was without doubt some natural variation in the years of this period due to actual conditions of precipitation. The average annual precipitation there is below normal, and the yearly amounts are generally considerably below, while the data for the Federal Building show an average above normal, with annual amounts all above 30 inches, except in the years 1910, 1912, and 1913. The record for the Major Block is even higher than that at the Federal Building. We must

therefore conclude that while the precipitation varies somewhat from year to year, it is not growing permanently less than it has been in former years.

COMPARISONS OF PRECIPITATION AT CHICAGO WITH PRECIPITATION AT OTHER PLACES

1. *Northern Illinois.*—Everyone knows how the amount of precipitation in individual storms will differ throughout a wide range from one place to another comparatively close by, and occasionally rain or snow occurs in one portion of the city and not in another.

TABLE LXX

MONTHLY AND ANNUAL PRECIPITATION IN INCHES FOR SELECTED STATIONS IN NORTHERN ILLINOIS AND EASTERN IOWA, FOR A VARYING NUMBER OF YEARS, FROM TIME OF OPENING THE DIFFERENT STATIONS TO 1910, INCLUSIVE

(Chicago record beginning with 1871)

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Aledo	1.54	1.40	2.39	2.60	4.56	3.81	3.96	3.51	3.59	2.00	1.69	1.22	32.27
Antioch	1.70	1.44	2.57	2.30	4.30	3.50	4.23	3.51	4.42	1.53	1.68	1.22	32.40
Ashton	1.64	1.87	2.86	2.30	4.74	3.50	3.98	3.82	3.13	1.90	1.72	1.47	32.93
Aurora	2.24	2.30	2.75	2.82	4.11	3.80	3.63	3.46	3.56	2.57	2.42	1.97	35.63
Cambridge	2.05	2.12	2.93	2.68	3.72	3.74	3.93	3.57	3.46	2.25	1.75	1.73	33.93
Chicago	2.10	2.30	2.51	2.87	3.54	3.49	3.53	3.10	3.09	2.38	2.52	2.09	33.52
Davenport, Ia	1.66	1.58	2.24	2.68	4.26	4.03	3.63	3.73	3.15	2.29	1.83	1.55	32.63
Dixon	2.05	1.62	2.65	2.52	5.04	3.49	4.24	3.13	3.33	1.94	1.57	1.70	33.28
Dubuque, Ia	1.50	1.42	2.19	2.85	4.24	4.44	4.27	3.10	3.71	2.50	1.82	1.62	33.66
Galva	1.80	1.56	2.57	2.97	4.08	3.98	3.77	3.52	3.50	1.88	1.73	1.47	32.83
Henry	1.94	1.68	2.58	3.03	4.19	4.28	3.72	3.01	3.24	1.99	2.35	1.80	33.81
Joliet	2.12	1.85	3.08	2.27	3.89	3.38	3.79	3.45	3.61	1.87	2.24	2.09	33.64
Kishwaukee	2.29	2.12	2.73	3.10	4.10	4.22	3.65	3.38	3.05	2.68	2.18	1.90	35.40
LaGrange	1.99	1.89	2.80	2.36	3.74	4.07	4.24	3.57	3.80	1.49	2.27	1.67	33.89
Lanark	1.41	1.23	2.31	2.79	4.64	4.10	4.23	3.51	3.55	2.23	1.96	1.59	33.58
Morrison	1.73	1.79	2.91	3.10	4.95	3.84	5.26	3.87	3.55	1.95	1.58	1.32	35.85
Ottawa	2.19	2.07	2.89	2.84	4.24	3.65	3.93	3.15	3.39	1.97	2.41	1.98	34.71
Streator	2.10	1.63	3.27	2.57	3.48	3.30	4.20	3.07	3.38	1.39	2.29	1.72	32.40
Sycamore	1.91	1.98	2.59	3.07	4.21	4.34	3.86	3.42	3.43	2.60	2.31	1.92	35.64
Tiskilwa	2.09	1.84	3.09	3.27	4.48	3.84	4.42	4.15	4.59	1.92	2.15	1.83	37.67
Walnut	1.96	1.78	3.03	2.68	4.55	3.86	4.32	3.40	3.97	1.58	1.61	1.44	34.18
Winnebago	1.98	1.77	2.82	3.18	4.30	4.07	3.92	3.42	3.52	2.23	2.04	1.80	35.05
Means	1.91	1.78	2.72	2.77	4.29	3.85	4.03	3.45	3.55	2.05	2.01	1.69	34.04

In the long run, however, the amounts for the year will average up to nearly the same values over large areas, the different portions of which are similarly located with respect to the rain-bearing winds. We find the mean annual temperature of Chicago to be about the same as that of northern Illinois (p. 53), and Table LXX presents the monthly and annual precipitation data for the same region, the mean annual value being 34.04 inches, only 0.52 inch greater than that of the city for the 40-year period shown. It is therefore apparent that Chicago receives practically the same amount of precipitation, distributed in about the same proportions throughout the year, as does the fertile prairie region surrounding.

NORMAL ANNUAL PRECIPITATION IN THE UNITED STATES, 1870-1901.

PLATE IX.

2. *Other portions of the United States.*—While the annual precipitation in northern Illinois varies but little, there is a very great difference in the amounts received throughout various other portions of the country, as shown on Plate IX. As a rule, the precipitation diminishes from the Atlantic coast westward to the Rocky Mountains and Plateau region, and from the Gulf coast northward through the Mississippi Valley, but in the Far West the precipitation is very little in the southern portion of the Pacific coast region, increasing steadily northward. The heaviest precipitation received in any section of the country is that which falls on the north Pacific coast, and there is a great difference to be noted in the amounts in the

TABLE LXXI

MONTHLY AND ANNUAL PRECIPITATION IN INCHES FOR 15 SELECTED CITIES OF THE UNITED STATES, FOR A VARYING NUMBER OF YEARS, FROM TIME OF OPENING THE DIFFERENT STATIONS TO 1910, INCLUSIVE

(Chicago record beginning with 1871)

(See Fig. 36)

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Portland, Ore.	6.57	5.78	5.03	3.08	2.42	1.65	0.59	0.61	1.71	3.46	6.62	7.13	44.65
San Francisco, Cal.	4.85	3.61	3.33	1.66	0.73	0.15	0.02	0.02	0.30	1.02	2.59	4.52	22.66
Yuma, Ariz.	0.41	0.53	0.37	0.09	0.03	Trace	0.16	0.53	0.23	0.22	0.37	0.53	3.47
Havre, Mont.	0.75	0.51	0.55	0.86	2.06	2.38	1.86	1.18	1.01	0.60	0.69	0.55	13.32
Denver, Colo.	0.47	0.49	1.02	2.08	2.54	1.44	1.75	1.38	0.98	0.94	0.57	0.61	14.26
El Paso, Tex.	0.49	0.41	0.34	0.25	0.33	0.58	2.04	1.72	1.28	0.96	0.54	0.49	9.43
Moorhead, Minn.	0.71	0.76	1.05	2.23	2.87	3.85	3.78	3.06	2.26	1.97	0.56	0.73	24.40
Omaha, Neb.	0.64	0.80	1.31	2.85	4.28	5.11	4.36	3.42	3.02	2.40	1.11	0.92	30.22
Galveston, Tex.	3.35	3.05	2.87	3.01	3.40	4.37	4.02	4.68	5.73	4.54	3.82	3.69	46.53
Marquette, Mich.	2.05	1.74	2.02	2.22	3.14	3.45	3.08	2.72	3.53	3.05	2.78	2.49	32.27
Chicago, Ill.	2.10	2.30	2.51	2.87	3.54	3.49	3.53	3.10	3.09	2.38	2.52	2.09	33.52
New Orleans, La.	4.54	4.59	5.03	5.00	4.26	6.10	6.25	5.68	5.11	2.89	3.54	4.55	57.55
Northfield, Vt.	2.51	2.42	2.70	2.22	2.83	3.21	3.54	3.68	2.98	2.36	2.77	2.70	33.56
New York, N.Y.	3.80	3.80	3.93	3.42	3.24	3.26	4.22	4.58	3.56	3.58	3.41	3.39	44.20
Jacksonville, Fla.	2.90	3.23	3.28	2.72	4.20	5.43	6.36	6.07	8.16	4.87	2.22	3.18	52.62

various sections of the mountain districts. Chicago's position as regards precipitation is most advantageous, its average of from 33 to 34 inches annually being ample for all purposes and activities suited to its latitude and temperature; whereas, much of the arid and semi-arid region between the eastern slope of the Rockies and the western coast ranges receives an average of less than 18 inches, and irrigation is necessary in order to bring crops to maturity.

In Table LXXI is given the average monthly and annual precipitation for 15 cities including Chicago, arranged roughly according to their positions in latitude and longitude, and these mean values are shown graphically in Fig. 36. The largest amounts of precipitation in the places east of the Rockies occur in the warm months of the year, while on the Pacific coast they occur chiefly in the winter

FIG. 36.—Average monthly precipitation in inches.

Fig. 36 shows the average monthly and annual precipitation at fifteen selected stations, including Chicago, taken across the northern, central, and southern portions of the United States from west to east (see Table LXXI).

time, and are so pronounced as to divide the year into two distinct seasons, one rainy and the other dry. The smallest amount of annual precipitation at any Weather Bureau station is 3.47 inches at Yuma, Ariz., and while the greatest shown in the table and graph is 57.55 inches at New Orleans, La., the amounts increase so rapidly in going northward on the Pacific coast that at the northernmost station, Neah Bay, Wash., the measurement averages more than 100 inches annually.

FREQUENCY OF PRECIPITATION, ANNUAL AND MONTHLY

As the amount of precipitation increases gradually from a winter minimum to a maximum in the summer season (p. 157), it might be judged from this that rain or snow occurs least frequently during the period of low temperatures from December to February. A day with precipitation, in the usage of the Weather Bureau, is one on which a measurable amount of rain, melted snow, sleet, etc., falls; that is, a day with 0.01 inch or more. The number of such days in Chicago for each month and year is set forth in Table LXXII, and the annual occurrence is shown in Fig. 37. From the table it will be seen that the frequency varies from month to month, and from year to year, as is the case with the amount of precipitation; yet, while the average amounts show a decided increase in the summer time (Fig. 32), the average frequency shows an appreciable falling off during that period. This is indicated by the line of mean frequency in Fig. 38, drawn from the averages at the bottom of the table. There is, of course, no fixed relation between the frequency of precipitation and its amount; but, nevertheless, the average fall on a rainy day in summer is nearly 75 per cent more than it is on a day of storm in the winter time. March, with an average of 11.9 days of precipitation, the greatest of any month in the year, has a mean precipitation of 2.51 inches, which gives 0.21 inch for each rainy day; in August, which has the least frequency, with an average of only 8.6 rainy days, the mean precipitation of 3.10 inches gives 0.36 inch for each. December and January have nearly the same frequency as May, 11.5, 11.3, and 11.6 days, respectively, although the amounts recorded in winter with its frequent light snow flurries are much less than in the spring month. February should be included with December and January in this comparison, because, as a matter of fact, its frequency of precipitation is somewhat greater than either of the two, although it appears in the table as only 10.7 days. Feb-

ruary, however, has only 28 days in which these 10.7 days of precipitation occur, and if reduced to the basis of 31 days, the length of the other winter months, the frequency becomes 11.8 days, second only to the record of March. It is therefore apparent that the time

TABLE LXXII

Monthly and Annual Frequency of Precipitation, 1871–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1871........	9	5	12	10	9	12	8	6	3	......	11	10	95
1872........	7	6	9	11	9	9	11	11	12	3	11	9	108
1873........	13	4	13	17	16	6	15	10	8	12	10	10	134
1874........	14	13	9	8	9	10	5	7	9	9	13	7	113
1875........	13	9	15	11	14	15	15	10	9	13	10	13	147
1876........	11	10	16	8	13	17	10	7	11	8	12	13	136
1877........	8	2	19	11	6	15	8	11	6	14	14	14	128
1878........	15	15	16	13	14	12	10	15	10	16	10	20	166
1879........	6	13	15	8	7	10	7	5	10	10	11	15	117
1880........	13	12	10	17	11	13	9	14	11	10	10	14	144
1881........	10	16	12	12	10	14	10	4	12	16	12	9	137
1882........	12	10	14	12	14	14	13	15	6	12	14	14	150
1883........	16	12	8	11	17	13	11	4	8	19	9	11	139
1884........	13	16	15	9	10	6	12	9	8	10	9	18	135
1885........	11	11	8	16	11	11	13	13	9	11	12	15	141
1886........	19	9	9	10	10	8	6	11	13	7	10	12	124
1887........	13	17	6	5	9	7	10	9	14	8	7	13	118
1888........	12	9	12	10	16	8	11	9	6	11	11	9	124
1889........	5	13	5	8	14	12	12	7	7	7	17	10	117
1890........	14	12	15	12	16	14	5	10	7	15	8	8	136
1891........	11	12	15	15	7	11	8	10	4	5	11	9	118
1892........	10	14	14	11	17	19	9	8	10	6	12	11	141
1893........	13	14	15	16	10	9	6	2	9	7	7	14	122
1894........	8	8	10	12	13	9	2	5	11	11	9	9	107
1895........	14	6	7	7	10	7	9	8	7	4	12	15	106
1896........	10	12	9	11	10	12	8	6	13	6	12	5	114
1897........	16	10	16	18	10	14	9	7	2	1	10	12	125
1898........	11	15	14	8	13	10	5	9	11	16	13	8	133
1899........	9	8	10	5	15	8	11	5	10	10	10	9	110
1900........	7	14	11	8	12	10	7	11	11	5	13	7	116
1901........	8	7	18	10	13	11	8	7	6	7	8	11	114
1902........	8	15	12	6	11	16	17	7	9	7	11	14	133
1903........	9	9	11	13	9	8	11	11	11	7	6	11	116
1904........	13	14	17	10	11	8	10	8	7	10	4	11	123
1905........	13	10	10	12	13	11	14	10	7	8	9	9	126
1906........	11	12	15	9	8	13	7	9	7	7	13	11	122
1907........	19	5	12	13	9	11	13	9	11	8	4	13	127
1908........	7	11	11	14	14	7	9	8	7	6	8	7	109
1909........	8	11	8	16	11	13	8	10	8	5	12	18	128
1910........	13	6	3	14	13	4	8	6	9	7	12	11	106
1911*.......	10	9	8	14	12	10	11	12	16	12	14	16	144
1912*.......	12	6	7	9	15	7	9	9	11	9	7	9	110
1913*.......	14	7	15	9	11	6	8	11	9	15	10	5	120
Means......	11.3	10.7	11.9	11.1	11.6	10.9	9.5	8.6	8.7	9.1	10.4	11.5	125.1
Greatest	19	17	19	18	17	19	17	15	14	19	17	20	166
Least.......	5	2	5	5	6	6	2	2	2	1	4	5	106

* Not included in means.

Table LXXII shows the number of days each month and year on which precipitation to the amount of 0.01 or more occurred. These values are graphically shown in Figs. 37 and 38.

of greatest frequency is the late winter and early spring, while that of least frequency is that of late summer and early fall.

The average annual frequency is 125 days, or about one day in every three, but the actual number has varied greatly during the

period of record. The largest number of days on which measurable precipitation has occurred in any year was 166 in 1878, one of the wettest years of the entire series and also the warmest up to 1911. The least number occurred in 1895 and 1910, when there were only 106 days of precipitation in each year, the former with 32.38 inches, being nearly normal in amount, and the latter with 26.86 inches, extremely dry. The year 1895 was colder than the normal, and 1910 was warmer. A comparison of the annual frequencies of precipitation and the annual amounts as shown in Tables LXV and LXXII with the accumulated departures in temperature (p. 16, Table III)

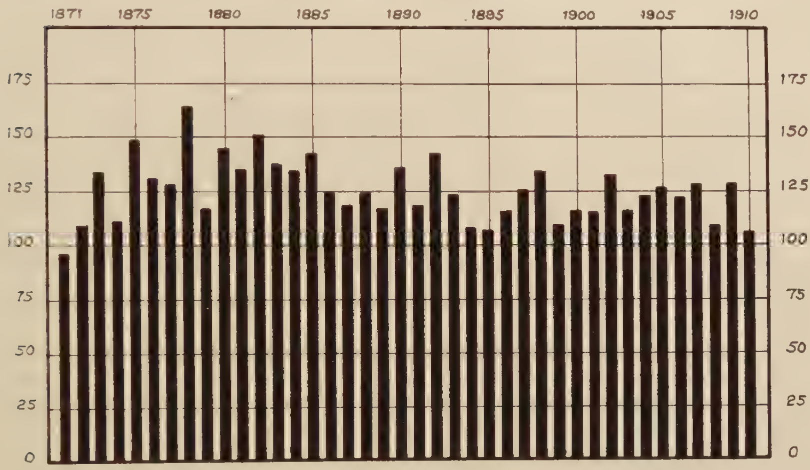


FIG. 37.—Variations in the annual frequency of days with appreciable precipitation, 1871–1910.

Fig. 37 shows the total number of days each year on which precipitation fell to the amount of 0.01 inch or over. The record for 1871 is for 11 months only (see Table LXXII).

shows no relation that can be determined definitely between the temperature and the occurrence and the amount of precipitation, both warm and cold years indicating a wide variation in each respect.

When precipitation of less than 0.01 inch occurs the amount is officially designated "trace," and the average number for the year is 44, distributed as appears in Auxiliary Table E.

AUXILIARY TABLE E

January	5	May	3	September	2
February	4	June	2	October	3
March	4	July	2	November	7
April	4	August	2	December	6

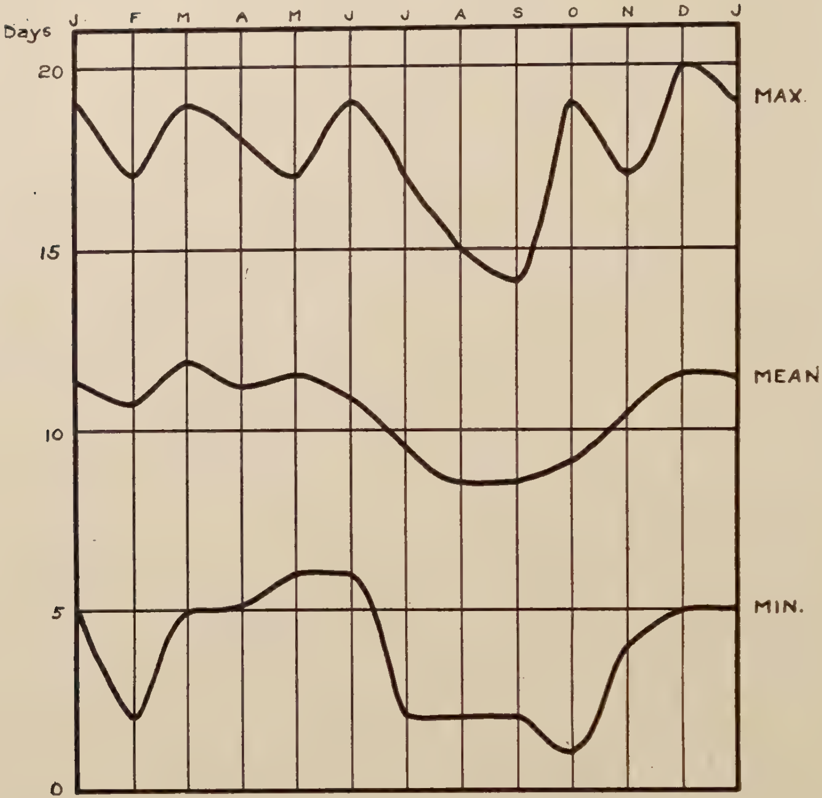


FIG. 38.—Monthly frequency of appreciable precipitation, 1871–1910.

TABLE LXXIII

AVERAGE MONTHLY AND ANNUAL NUMBER OF DAYS WITH PRECIPITATION (0.01 OR MORE) FOR 15 SELECTED CITIES OF THE UNITED STATES, FOR A VARYING NUMBER OF YEARS

(See Fig. 39)

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Portland, Ore.	19	17	17	15	13	11	4	4	8	13	17	20	158
San Francisco, Cal.	12	11	11	7	4	2	1	0§	2	5	6	10	71
Yuma, Ariz.	2	2	2	0*	0†	0‡	1	2	1	1	1	2	14
Havre, Mont.	8	7	6	6	9	10	7	6	7	6	6	7	85
Denver, Colo.	4	5	7	9	11	8	9	9	5	5	4	5	81
El Paso, Tex.	4	3	2	2	2	3	8	8	6	4	3	3	48
Moorhead, Minn.	8	9	8	8	11	11	10	9	8	8	6	9	105
Omaha, Neb.	7	6	8	10	12	11	10	9	8	7	5	7	100
Galveston, Tex.	11	10	9	6	6	7	9	9	10	7	8	10	102
Marquette, Mich.	16	14	13	12	10	12	12	12	12	14	15	17	159
Chicago, Ill.	11	11	12	11	12	11	9	9	9	9	10	11	125
New Orleans, La.	10	10	9	7	9	13	15	14	11	6	8	10	122
Northfield, Vt.	14	11	13	12	13	13	14	13	12	13	13	13	154
New York, N.Y.	12	10	12	11	11	10	12	10	9	9	10	10	126
Jacksonville, Fla.	9	9	8	7	10	13	15	15	14	10	8	8	126

* Precipitation was observed 9 days in 20 years.

† Precipitation was observed 6 days in 20 years.

‡ No precipitation was observed in 20 years.

§ Precipitation was observed 19 days in 40 years.

The greater number of such days is in the colder season, and the fall is usually in the form of snow flurries. This is because the amount of water vapor in saturated air is much less during times of low temperatures, and consequently not nearly so much cooling is necessary in order to start condensation. In March, 1899, there were 14 days recorded on which only a "trace" occurred, and in November, 1887, there were 12 days. Usually, however, the occurrence is much nearer the averages shown, although in several instances 10 or 11 days were recorded.

Table LXXIII and Fig. 39 give data on the annual and monthly occurrence of precipitation for the same cities given in Table LXXI and Fig. 36, and a comparison of the two sets will indicate at a glance the general relation between the frequency of precipitation and the amount of depth for the various sections represented.

WET SPELLS

While the summer rainfall is on the average the heaviest of that of any portion of the year, there is no recurring period which can be called a wet season, such as is experienced in the winter on the Pacific coast (p. 165). However, there occur at times in all months periods in which precipitation is recorded on several successive days, and other periods of greater or lesser extent in which precipitation falls in extraordinarily heavy amounts.

Table LXXIV contains the greatest number of consecutive days in each month with precipitation of 0.01 inch or more, and Table LXXV contains the longest continuous periods with precipitation of "trace" or more on each day. In the first case the average is about 4 days each month during the winter and spring, and about 3 days each month during the summer and autumn. The longest period on record is 11 days, from August 24 to September 3, inclusive, in 1880, and this period is included in that of 17 days, given in the second table, extending to September 9. There were no heavy rainfalls on any day during this time, however, and the total amount for the 17 days was but 3.72 inches. The next longest wet period is one of 10 days, from June 11 to 20, 1876, and the only heavy fall in this time occurred on the 16th—1.87 inches. The longest period on which a "trace" or more was recorded (Table LXXV) is 18 days, from January 17 to February 3, 1904, and the precipitation was nearly all in the form of rain. It was light for the most part, except on January 20, when 1.05 inches fell. There are three such periods

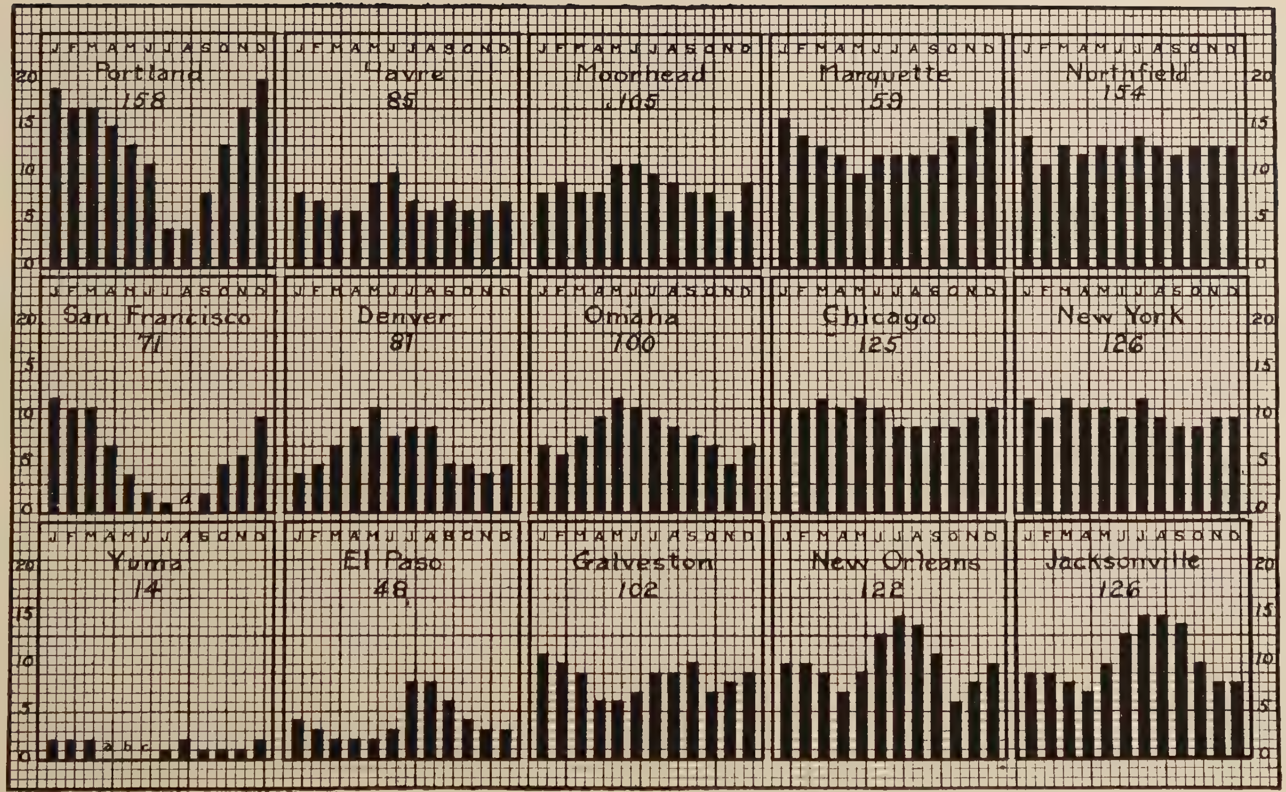


FIG. 39.—Average number of days with precipitation.

a = precipitation (0.01 or more), observed but 9 days in 20 years; *b* = precipitation (0.01 or more), observed but 6 days in 20 years; *c* = no precipitation (0.01 or more) in 20 years; *d* = precipitation (0.01 or more), observed but 19 days in 40 years.

Fig. 39 shows the average monthly and annual number of days with precipitation (0.01 or more) at 15 selected stations, including Chicago, taken across the northern, central, and southern portions of the United States from west to east. See Table LXXIII.

of 16 days each, in February, 1898, March, 1906, and January, 1907, respectively, and although they are considerably longer than the average, they were not marked by heavy precipitation at any time. The average length of the longest period each year with a fall of 0.01

TABLE LXXIV

Longest Period Each Month and Year of Consecutive Days with 0.01 or More of Precipitation, 1871–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1871	3	1	3	3	3	3	2	3	2	2	3	3	3
1872	2	2	2	4	2	3	4	3	3	2	3	6	6
1873	5	2	3	5	4	2	4	3	2	6	4	4	6
1874	7	[b]5	2	2	2	4	2	3	3	3	4	2	7
1875	3	5	6	6	5	4	6	3	3	5	2	6	6
1876	4	3	6	4	4	10	5	3	7	[b]4	2	3	10
1877	3	2	6	4	3	4	4	3	3	5	5	7	7
1878	[a]4	7	4	5	3	3	3	3	3	4	3	6	7
1879	2	4	3	[b]5	2	3	2	2	3	3	3	3	5
1880	4	5	3	4	3	6	2	[c]11	3	3	3	3	11
1881	2	6	4	3	4	4	3	2	6	8	3	3	8
1882	2	4	5	5	4	7	4	4	[b]5	4	4	3	7
1883	4	3	3	3	4	5	4	2	3	6	3	4	6
1884	2	4	3	[a]3	2	2	4	2	2	2	3	5	5
1885	4	6	2	9	2	4	4	4	3	3	4	3	9
1886	4	2	[a]5	6	4	4	2	2	6	3	3	3	6
1887	[a]4	5	2	3	4	[b]4	3	3	[b]8	2	4	3	8
1888	4	2	4	3	3	3	3	[a]5	3	2	3	4	5
1889	2	3	3	3	[b]5	4	5	2	2	[b]4	6	3	6
1890	5	[b]5	4	5	6	3	1	2	2	4	4	5	6
1891	[a]4	5	3	4	2	4	2	3	2	2	4	2	5
1892	3	2	2	3	[a]5	8	3	2	7	[b]3	3	3	8
1893	3	[a]4	7	6	[c]4	3	2	1	3	[b]5	4	4	7
1894	2	3	4	[a]5	4	3	1	2	8	3	4	3	8
1895	5	2	2	3	4	3	2	4	2	2	4	5	5
1896	4	5	2	3	4	2	2	2	4	4	4	2	5
1897	5	3	4	5	2	5	3	1	1	1	3	6	6
1898	3	6	5	2	4	7	3	3	4	4	4	2	7
1899	2	3	2	1	4	3	5	2	3	3	3	6	6
1900	5	4	3	3	4	3	2	4	4	2	5	2	5
1901	2	3	5	4	5	3	2	2	2	5	3	4	5
1902	4	[c]9	4	2	3	4	8	1	3	2	2	4	9
1903	2	2	4	6	3	2	4	4	5	3	2	3	6
1904	3	3	3	5	5	2	4	4	1	4	3	5	5
1905	3	2	3	4	3	3	5	4	[a]4	3	2	3	5
1906	3	3	6	3	2	4	[b]4	4	3	2	6	2	6
1907	6	4	5	3	3	4	4	2	2	2	2	3	6
1908	2	2	3	6	5	3	2	3	2	5	4	3	6
1909	2	3	2	4	3	5	3	5	3	2	4	5	5
1910	3	3	2	6	4	1	2	2	4	4	4	2	6
1911*	5	5	5	[b]5	5	3	3	5	6	3	4	4	6
1912*	3	2	2	2	4	3	2	5	5	4	3	3	5
1913*	3	[a]4	4	4	3	3	3	2	[a]3	5	[a]3	2	6
Average (1871–1910)	3	4	4	4	4	4	3	3	3	3	3	4	[illegible]

* Not included in averages.

Note.—([a]), ([b]), ([c]), etc., indicate that period extends into either preceding or following month, 1, 2, 3, etc., days.

inch or more is 6 consecutive days; that with a fall of "trace" or more, 10 consecutive days.

The amount of precipitation during a wet spell is of quite as much importance as the duration of the fall. The two previous

tables give simply the longest periods each month and year of consecutive days of precipitation, and in many instances these periods cannot properly be regarded as wet spells. Table LXXVI, however, includes all periods of 10 consecutive days or less in which the amount

TABLE LXXV

LONGEST PERIOD EACH MONTH AND YEAR OF CONSECUTIVE DAYS WITH TRACE OR MORE OF PRECIPITATION, 1871–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1871	3	2	5	5	3	3	2	3	2	2	3	3	5
1872	2	2	2	4	[a]2	3	4	3	3	2	3	3	4
1873	5	2	3	5	4	2	4	3	2	6	4	4	6
1874	7	[b]6	2	3	3	4	2	3	3	3	4	3	7
1875	4	5	10	6	5	4	6	4	3	5	2	6	10
1876	5	3	6	6	6	10	5	3	7	[b]4	7	5	10
1877	4	3	6	5	3	5	4	3	3	6	6	7	7
1878	[b]7	8	4	5	3	3	3	3	3	4	3	6	8
1879	3	5	3	[a]5	3	3	2	2	3	3	5	3	5
1880	4	5	3	4	3	6	3	[a]3	[i]17	[a]4	3	5	17
1881	5	12	[c]8	[d]6	4	5	3	2	6	8	4	[b]6	12
1882	3	6	12	6	[e]7	9	4	[b]12	[b]5	4	5	3	12
1883	4	3	4	4	4	5	4	2	3	6	3	5	6
1884	[b]4	6	4	5	2	2	4	2	2	[a]3	6	6	6
1885	4	6	2	9	[c]4	4	7	4	7	[b]9	12	8	12
1886	5	[c]5	[b]5	8	4	4	[a]3	2	7	3	[b]8	7	8
1887	6	8	6	5	[b]5	3	[a]6	4	[b]8	6	6	7	8
1888	6	3	[a]6	4	6	4	3	[b]6	3	2	3	5	6
1889	3	5	3	4	10	5	5	2	4	[b]4	6	4	10
1890	5	[a]8	4	5	6	7	2	3	4	4	4	[a]6	8
1891	[c]7	5	6	[b]8	3	4	2	3	2	3	10	3	10
1892	4	7	[a]3	3	7	15	3	2	8	2	4	5	15
1893	[c]8	10	8	[e]12	4	3	[a]3	2	7	[b]5	5	4	12
1894	5	4	4	[c]7	4	4	3	2	8	3	7	6	8
1895	6	3	3	5	5	3	4	4	2	2	5	6	6
1896	5	5	4	[b]4	4	4	3	3	6	4	5	5	6
1897	9	5	8	6	3	5	3	2	2	2	3	6	9
1898	5	16	5	3	5	7	3	3	4	6	4	7	16
1899	3	[c]7	10	3	4	5	6	2	10	4	3	6	10
1900	9	7	7	6	4	3	3	5	7	2	7	5	9
1901	[e]13	3	[b]8	7	5	5	5	2	4	6	4	8	13
1902	7	[a]10	8	4	8	5	8	2	6	3	5	8	10
1903	7	4	8	6	[b]13	3	4	10	5	3	3	7	13
1904	[c]18	8	[c]5	8	10	[a]4	4	4	3	5	3	7	18
1905	6	5	5	6	7	4	7	5	[a]4	7	[c]7	3	7
1906	5	5	16	3	3	4	[b]4	4	3	3	6	4	16
1907	16	6	5	7	5	5	4	3	3	2	3	6	16
1908	3	5	[b]4	7	7	3	[c]7	3	2	5	4	5	7
1909	4	4	5	5	4	5	4	5	3	7	8	7	8
1910	4	5	2	6	4	1	4	3	5	4	5	[a]8	8
1911*	8	5	6	[b]6	6	3	3	5	6	4	7	5	8
1912*	[d]6	[f]4	3	2	4	3	[a]4	7	5	4	3	5	7
1913*	7	[e]8	6	5	11	5	3	4	4	7	6	2	11
Average (1871–1910)	6	6	6	6	5	5	4	3	5	4	5	5	10

* Not included in averages.

NOTE.—([a]), ([b]), ([c]), etc., indicate that period extends into either preceding or following month, 1, 2, 3, etc., days.

of precipitation equaled or exceeded the average for the month in which it occurred, or was proportional to it in longer periods, and indicates the limiting dates and the amount which fell during the time. These wet spells are confined to no particular season or month.

TABLE LXXVI

WET SPELLS, 1871–1911

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Number of Wet Spells
1871	15 3 2.80			19 9 3.29		23 7 4.50					14 8 2.71	24 3 2.97	5
1872									12 6 3.04 29 8 3.28				2
1873				11 11 4.81	9 9 5.35							12 10 4.05	3
1874	24 7 2.41												1
1875									10 3 3.58				1
1876		13 6 2.27	24 10 2.87						14 10 3.61				3
1877						26 9 3.66				21 5 3.55	9 9 3.71		3
1878				27 10 3.92			26 3 4.15						2
1879							9 4 4.34						1
1880	11 9 2.27			25 10 3.82									2
1881		12 6 3.52				13 9 4.74					13 3 3.60		3
1882				9 8 3.19 26 5 2.93									2
1883		24 11 3.45			10 9 4.93					29 6 3.03	9 5 3.85		4
1884		13 10 2.49	28 11 4.62									31 5 2.37	3
1885						8 7 3.88		3 2 6.36 25 3 3.93					3
1886									19 11 5.82				1
1887		2 12 2.27 17 10 3.25							30 10 3.34				3
1888													0
1889							19 7 3.89 30 5 4.50						2
1890													0
1891								27 5 3.09					1
1892						26 10 8.39							1
1893													0

TABLE LXXVI—*Continued*

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Number of Wet Spells
1894									10 8 7.32				1
1895	5 5 2.55							29 7 5.77		9 4 2.66		25 9 6.15	4
1896									14 4 3.85	26 8 2.75			2
1897													0
1898	26 7 2.37		19 9 2.98										2
1899													0
1900													0
1901													0
1902			15 4 2.72										1
1903													0
1904								22 4 3.16					1
1905					13 4 3.85								1
1906													0
1907	19 9 2.47												1
1908								17 7 5.83					1
1909				29 4 3.20				15 5 4.80				13 10 2.88	3
1910	21 10 2.15												1
1911								17 8 3.24					1
Number of wet spells	7	6	4	7	3	5	4	8	8	4	4	5	65

Table LXXVI includes all periods of 10 consecutive days or less in which the amount of precipitation equaled or exceeded the average for that month, or was proportional to it in longer periods. The first figure indicates the last day of the wet spell, the second indicates the duration in days, and the third figure indicates the total amount of precipitation in inches.

They have not, however, occurred in every year of the record, and the table shows a much smaller number, relatively, during the years in which the measurements were made at the Chicago Opera House Building and the Auditorium Tower (p. 152). The most pronounced wet spell was that of 10 days' duration, from June 17 to 26, 1892, in which a total rainfall of 8.39 inches occurred. Other remarkable periods of the kind were those of September 3–10, 1894, with a total fall of 7.32 inches, and of August 2–3, 1885, with 6.36 inches. Later in this same August 3.93 inches fell within 3 successive days, and the total precipitation of the month, 11.28 inches, is the greatest

monthly fall on record for the city. As a result of these August rainfalls innumerable basements were flooded and the capacity of the sewers overtaxed, the condition resulting in the first agitation for the building of the Drainage Canal. In December, 1895, occurred a period of 9 days' precipitation, all in the form of rain, totaling 6.15 inches. In August, 1908, there was a period of 7 days with a total precipitation of 5.83 inches, and of this amount 2.31 inches fell on the 11th, 2.03 inches on the 12th, and 1.23 inches on the 15th.

ANNUAL NUMBER OF DAYS WITH PRECIPITATION OF STATED AMOUNTS

The annual number of days with precipitation of "trace" or more and of 0.01 inch or more has already been given. The latter data are repeated in Table LXXVII, which gives in addition the

TABLE LXXVII

ANNUAL NUMBER OF DAYS WITH PRECIPITATION OF STATED AMOUNTS, 1871–1913

Year	Less than 0.01 Inch	0.01 Inch or More	0.04 Inch or More	0.25 Inch or More	1.00 Inch or More	Year	Less than 0.01 Inch	0.01 Inch or More	0.04 Inch or More	0.25 Inch or More	1.00 Inch or More
1871.......	14	95†	81	37	10	1895......	45	106	79	37	7
1872.......	3	108	71	36	4	1896......	60	114	89	41	8
1873.......	7	134	101	42	8	1897......	49	125	92	36	3
1874.......	12	113	84	34	5	1898......	56	133	108	40	6
1875.......	12	147	106	40	8	1899......	72	110	84	32	2
1876.......	17	136	98	41	9	1900......	57	116	95	42	4
1877.......	20	128	99	57	7	1901......	65	114	80	30	4
1878.......	9	166	115	47	9	1902......	62	133	103	47	8
1879.......	24	117	91	30	8	1903......	76	116	87	39	4
1880.......	36	144	107	53	6	1904......	69	123	90	29	5
1881.......	35	137	110	53	10	1905......	56	126	96	40	5
1882.......	42	150	107	48	10	1906......	54	122	91	34	9
1883.......	28	139	105	49	10	1907......	58	127	98	48	8
1884.......	29	135	107	39	6	1908......	50	109	88	41	9
1885.......	52	141	94	41	9	1909......	60	128	100	49	8
1886.......	53	124	91	33	3	1910......	57	106	83	35	4
1887.......	78	118	88	43	5	1911*.....	52	144	111	46	4
1888.......	42	124	91	34	5	1912*.....	63	110	85	34	6
1889.......	45	117	87	41	8	1913*.....	58	120	80	30	9
1890.......	38	136	101	44	6						
1891.......	47	118	81	28	5	Mean......	43.2	125.1	93.8	40.2	6.4
1892.......	41	141	104	46	4						
1893.......	48	122	91	37	3	Greatest ...	78	166	115	57	10
1894.......	51	107	79	37	4	Least......	3	106	71	28	2

* Not included in means.

† For 11 months.

number of days in each year with precipitation of 0.04 inch or more, 0.25 inch or more, and of 1.00 inch or more, and also the number of days with less than 0.01 inch precipitation. In the matter of "traces," from the small number recorded in the early years of the record it will be apparent that as close attention to very light showers and snow flurries was not given by the observers as is the case in the

present day. The numbers vary greatly from year to year, but the average annual occurrences, beginning with the smallest amount, are 43.2, 125.1, 93.8, 40.2, and 6.4 days, respectively. With the exception of the first of these means, each includes the occurrence of all the classes following, but the individual averages can be secured by taking the difference between any mean and that immediately following; and the results are given in Auxiliary Table F.

AUXILIARY TABLE F

Average Number of Days with Precipitation of Certain Amounts

Amount in Inches	No. Days
"Trace"	43.2
0.01 to 0.03 inch	31.3
0.04 to 0.24 inch	53.6
0.25 to 0.99 inch	33.8
1.00 inch or over	6.4

From these figures it is apparent that precipitation of 0.04 to 0.24 inch occurs more frequently than that of any other class, while amounts so light as to be unmeasureable are next in order of occurrence. In no year of the record have there been less than 106 days of appreciable precipitation; nor have there been more than 10 days with 1.00 inch or more, although this number was recorded in three successive years, 1881, 1882, and 1883, the wettest 3-year period since the official observations began.

EXCESSIVE PRECIPITATION

In many kinds of building, street, sewer, and dredging work information as to the greatest amounts of precipitation that have occurred in short spaces of time is of prime importance. Tables containing such data for Chicago have been prepared so far as possible. The records of excessive precipitation in earlier years, however, are in many cases either fragmentary or wanting altogether, and it was not until after the installation of the automatic recorders in 1897 that more complete data became available. Excessive precipitation is distinguished in several different ways, and the various classes are discussed in the following paragraphs.

1. *Precipitation of 1 inch or more an hour.*—Table LXXVIII gives the dates of rainfall when the amounts reached or exceeded 1 inch an hour, the total fall and the time being entered in each case. While the record covers the period from 1871 to 1913, inclusive, it is obviously incomplete. In the earliest days the observers were required to note such occurrences, but in the absence of automatic

registers, the record for a single hour cannot be depended upon unless the total fall of the storm happened within that time. Some exceptionally heavy rainfalls will be seen in the tabulation, among the most pronounced of which are those of June 23, 1871, 2.13 inches in 1 hour; May 25, 1896, 1.24 inches in 15 minutes; July 27, 1889, 1.18 inches in 54 minutes; May 11, 1905, 1.12 inches in 26 minutes; August 5, 1905, 1.18 inches in 23 minutes.

TABLE LXXVIII

EXCESSIVE PRECIPITATION—1.00 INCH OR MORE AN HOUR, 1871–1913

April				May				June				July			
Year	Amount	Time	Date	Year	Amount	Time	Date	Year	Amount	Time	Date	Year	Amount	Time	Date
				1896..	1.24	$0^{h}15^{m}$	25	1871..	1.93	$0^{h}30^{m}$	19	1889..	1.55	$0^{h}35^{m}$	18–19
					1.34	1 0	25		2.13	1 00	23		1.18	0 54	27
				1905..	1.12	0 26	11	1892..	1.60	1 00	23	1890..	1.00	0 34	14
									1.05	1 00	18		1.04	1 00	14
												1891..	1.10	0 43	6
													1.20	1 00	7
												1906..	1.17	0 20	15
													1.64	1 00	28
												1912..	1.00	0 41	7

August				September				October				November			
Year	Amount	Time	Date	Year	Amount	Time	Date	Year	Amount	Time	Date	Year	Amount	Time	Date
1896..	1.17	$0^{h}37^{m}$	6	1905..	1.21	$0^{h}45^{m}$	1					1911..	1.00	$1^{h}00^{m}$	11
1905..	1.18	0 23	5	1912..	1.41	0 39	2								
1907..	1.00	0 57	16												
1908..	1.04	0 23	11												
1909..	1.34	0 35	14												
	1.26	0 34	14												
1909..	1.00	0 41	27												
1910..	1.52	0 38	23												
1912..	1.00	0 39	9												

Table LXXVIII contains the dates on which precipitation equaled or exceeded 1.00 inch in one hour, together with the amount, and duration in hours and minutes, in each case. The record is incomplete, but includes years from 1871 to 1913.

2. *Precipitation of 2.50 inches or more in twenty-four consecutive hours.*—Table LXXIX gives the dates of precipitation when the amounts equaled or exceeded 2.50 inches in twenty-four consecutive hours covering the period from 1871 to 1913, inclusive. The heaviest rainfall in this record is that of August 2–3, 1885, when 6.19 inches fell within a space of twenty-four hours, 6.36 inches falling in the entire storm (p. 176). Probably the heaviest rainfall on

record in proportion to the actual time of occurrence was that of July 27, 1889, when the 4.02 inches shown fell in 3 hours and 34 minutes, 1.18 inches of this amount falling in 54 minutes, as given in the preceding table.

3. *Greatest precipitation in twenty-four consecutive hours, monthly and yearly.*—The table discussed in the paragraph immediately above gives only the instances in which the rate of precipitation reached or passed 2.50 inches in any twenty-four hours. Table

TABLE LXXIX

EXCESSIVE PRECIPITATION—2.50 INCHES OR MORE IN TWENTY-FOUR HOURS, 1871–1913

January			February			March			April		
Year	Amount	Date	Year	Amount	Date	Year	Amount	Date	Year	Amount	Date
						1884...	3.26	25–26	1909...	2.75	29

May			June			July			August		
Year	Amount	Date	Year	Amount	Date	Year	Amount	Date	Year	Amount	Date
1873....	2.82	1–2	1871...	2.57	22–23	1878...	4.14	25–26	1885...	6.19	2–3
1879....	2.52	25	1877...	2.65	25–26	1879...	3.25	6–7	1895...	3.65	23–24
1890....	2.60	9–10	1881...	2.57	6–7	1889...	4.02	27	1908...	4.34	11–12
1905....	2.78	11	1885...	3.44	2–3	1906...	2.91	28	1909...	3.52	14–15
			1892...	3.11	23–24						
			1898...	2.50	25						

September			October			November			December		
Year	Amount	Date	Year	Amount	Date	Year	Amount	Date	Year	Amount	Date
1872....	2.70	28–29	1877...	2.55	19–20	1881...	3.35	11–12	1871...	2.50	23
1875....	3.44	9				1883...	3.39	5–6	1895...	2.66	18–19
1894....	3.35	3–4								2.51	19–20
1906....	2.73	28–29									

Table LXXIX contains the dates on which precipitation equaled or exceeded 2.50 inches in any twenty-four consecutive hours, giving the amount in each instance, from 1871 to 1913.

LXXX shows the greatest 24-hour falls for each month and year of the official record, and it will be apparent that in the majority of cases the largest amounts occurring in twenty-four hours for the various months are less than 1.00 inch. There is, however, a considerable number of from 1.00 inch to 2.50 inches, but over the latter limit occurrences are comparatively few, and are confined for the most part to the late spring and summer period, when thunderstorms are at their greatest frequency. Fig. 40 shows the greatest 24-hour falls for each year of the official period to 1910.

TABLE LXXX

GREATEST PRECIPITATION (IN INCHES) IN TWENTY-FOUR CONSECUTIVE HOURS, 1871-1913

Year	January		February		March		April		May		June		July		August		September		October		November		December		Annual		
	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Month	Date
1871......	1.20	13	0.78	17–18	0.71	2	2.41	10	1.03	25–26	2.57	22–23	1.57	3–4	0.73	4	0.53	15	1.41	31	1.24	10	2.50	23	2.57	June	22–23
1872......	0.26	19–20	0.42	5	1.88	30–31	0.71	6–7	0.96	29	1.21	6–7	1.14	20–21	0.89	27–28	2.70	28–29	0.45	5–6	0.77	4–5	0.04	1–2	2.70	Sept.	28–29
1873......	0.81	2	0.23	26–27	0.26	30	1.66	5–6	2.82	1–2	0.57	26	1.35	4	0.58	1	1.94	28–29	1.73	3–4	0.54	23	1.21	2–3	2.82	May	1–2
1874......	1.04	21–22	0.57	12–13	1.20	3–4	1.45	19–20	0.64	15	1.45	8	0.43	7	2.19	21–22	1.28	4–5	1.56	28	0.79	22–23	0.31	16	2.19	Aug.	21–22
1875......	0.58	17–18	0.65	10	0.36	14–15	1.03	12–13	1.10	28	1.70	21–22	2.29	27–28	1.22	15	3.44	9	1.49	5–6	0.35	25–26	0.66	24	3.44	Sept.	9
1876......	1.53	18	1.94	8–9	1.67	15–16	1.51	12–13	0.79	6	1.87	16	1.91	9–10	1.82	29–30	1.72	13	0.44	13	0.93	1–2	0.14	17	1.94	Feb.	8–9
1877......	1.02	15–16	0.06	22–23	0.91	11–12	0.68	18–19	0.73	7	2.65	25–26	1.47	2	1.26	13–14	1.19	26	2.55	19–20	1.66	8	1.02	18	2.65	June	25–26
1878......	0.72	31	0.76	10–11 20–21	1.50	27–28	1.55	24–25	1.66	18–19	0.87	29	4.14	25–26	1.36	18	1.16	24–25	1.41	16	0.22	15–16	0.69	21	4.14	July	25–26
1879......	0.41	15–16	0.36	25–26	0.87	5–6	1.48	9–10	2.52	25	1.02	21	3.25	6–7	0.16	6	0.40	13–14	1.43	16–17	1.50	27–28	1.10	9	3.25	July	6–7
1880......	0.95	3–4	1.17	17–18	1.15	26–27	1.65	24	1.26	8	1.17	14–15	0.84	8	1.25	24–25	0.89	18–19	1.91	2–3	0.45	10	0.45	4–5	1.91	Oct.	2–3
1881......	0.24	15	1.34	7	1.04	19	0.86	11–12	0.68	8–9	2.57	6–7	1.81	20–21	0.30	6	1.10	15–16	1.29	14–15	3.35	11–12	1.14	21	3.35	Nov.	11–12
1882......	0.49	7–8	1.35	28	1.43	9	1.58	22–23	1.77	26–27	1.92	2–3	1.00	30–31	1.69	22–23	0.63	1–2	1.17	8–9	0.45	5–6	0.81	20	1.92	June	2–3
1883......	0.60	16–17	1.94	16	0.18	6	1.38	4–5	2.37	9–10	1.20	12	1.77	4–5	1.05	27–28	0.68	23	1.94	25	3.39	5–6	0.52	22–23	3.39	Nov.	5–6
1884......	0.39	1–2	1.13	12	3.26	25–26	1.74	15	0.68	1	0.64	1–2	1.46	23–24	1.27	28	1.09	27	1.39	7–8	0.87	3–4	0.95	28–29	3.26	Mar.	25–26
1885......	1.24	5–6	0.99	8–9	0.20	6–7	1.71	17	1.23	29	3.44	2–3	0.83	9	6.19	2–3	1.65	8	2.22	19	1.17	5–6	1.29	8–9	6.19	Aug.	2–3
1886......	0.71	15–16	0.53	11	0.54	20–21	0.42	29	0.52	9	0.58	15–16	0.61	13	1.39	28–29	2.11	9–10	0.59	14	0.74	16–17	0.37	12–13	2.11	Sept.	9–10
1887......	1.39	22	1.23	17–18	0.48	5–6	0.18	22	0.49	30–31	0.70	20	0.45	3	1.24	13–14	1.33	21–22	0.82	22–23	0.66	26–27	1.04	3	1.39	Jan.	22
1888......	0.51	6	0.76	24–25	1.01	25–26	0.90	9–10	2.43	27–28	0.97	27	1.29	31	1.00	2	0.45	16	1.31	18	1.10	7–8	0.98	25–26	2.43	May	27–28
1889......	0.68	8–9	0.44	15–16	0.93	30–31	1.03	11–12	1.42	10–11	0.68	16	4.02	27	0.16	8–9 13–14	2.08	4–5	0.82	12	1.47	1	0.95	9–10	4.02	July	27
1890......	0.94	12–13	0.53	7, 25	0.60	10–11	0.90	13	2.60	9–10	1.03	10–11	1.31	14	1.47	20–21	0.98	7–8	1.16	25–26	0.84	16–17	0.47	31	2.60	May	9–10
1891......	1.25	1	1.25	1	0.58	30	1.48	9	0.84	22	0.79	28	1.28	6–7	1.92	23–24	0.20	2–3	0.21	6–7	0.84	8–9	0.56	6	1.92	Aug.	23–24
1892......	0.57	Dc.31 Jan. 1	0.42	7	0.59	26–27	0.70	3–4	1.66	5	3.11	23–24	1.41	2	0.61	24–25	0.82	10–11	0.78	24–25	1.43	16–17	0.86	13	3.11	June	23–24
1893......	0.60	24	0.87	17–18	0.55	8–9	1.32	26	0.91	23	1.46	20	1.14	13–14	0.16	16	0.95	21–22	0.80	2	0.91	26–27	0.81	2–3	1.46	June	20
1894......	0.64	20	1.02	12–13	1.11	5–6	1.37	9–10	1.01	5–6	0.63	25–26	0.53	19–20	0.25	10–11	3.35	3–4	0.34	21–22	0.43	2–3	1.01	26–27	3.35	Sept.	3–4
1895......	0.91	25–26	0.91	5–6	0.73	31	0.38	8	0.57	4	0.60	25–26	0.86	7	3.65	23–24	0.58	15	0.38	6–7	1.77	6–7	2.66	18–19	3.65	Aug.	23–24
1896......	0.58	22–23	1.52	2–3	0.30	10–11	1.18	20	1.47	25	0.92	7–8	1.81	26–27	1.24	6	2.42	14	0.92	17	0.57	5	0.06	4	2.42	Sept.	14
1897......	1.24	2–3	0.45	20	1.00	23–24	0.54	23	0.45	22–23	2.01	16–17	0.37	5	0.83	1	0.43	19–20	0.18	11	0.85	14	0.56	13–14	2.01	June	16–17
1898......	1.13	20	1.05	19–20	1.84	18–19	0.43	8–9	0.52	4–5	2.50	25	1.22	28	0.89	3–4	1.20	4–5	0.86	25–26	1.20	10	0.42	21–22	2.50	June	25
1899......	0.24	4	0.98	25–26	0.67	17–18	0.06	20	0.92	28–29	0.67	14	2.17	3–4	0.30	4–5	0.66	17–18	0.85	27–28	0.46	13–14	1.30	10–11	2.17	July	3–4
1900......	0.70	17–18	1.15	27–28	0.66	5–6	0.32	17	1.25	7–8	0.70	6	1.48	24	0.86	17	0.38	28–29	0.79	29	1.34	18–19	0.28	31	1.48	July	24
1901......	0.35	9	1.14	3–4	0.80	10	0.15	21–22	1.04	6	1.03	5–6	1.56	1	0.93	17–18	1.96	11	0.57	11–12	0.34	22–23	0.81	13	1.96	Sept.	11
1902......	0.30	20–21	0.86	27–28	2.02	11–12	1.95	25	1.64	23–24	1.25	28–29	1.53	17–18	0.57	13	1.64	23–24	0.71	25	1.22	4–5	0.49	19–20	2.02	Mar.	11–12
1903......	0.35	2–3	1.10	3–4	0.76	7	1.29	10–11	0.30	25	0.68	22	1.23	17	1.13	26–27	1.54	9–10	0.49	7	0.14	28	1.23	12	1.54	Sept.	9–10

TABLE LXXX—*Continued*

GREATEST PRECIPITATION (IN INCHES) IN TWENTY-FOUR CONSECUTIVE HOURS, 1871–1913

Year	January		February		March		April		May		June		July		August		September		October		November		December		Annual		
	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Month	Date
1904......	1.15	19–20	0.48	17–18	0.85	24–25	1.24	23–24	0.59	8–9	0.16	4	0.91	30–31	1.83	21–22	1.25	18	0.98	4–5	0.28	9	0.28	11–12 25–26	1.83	Aug.	21–22
1905......	0.56	11	0.60	24–25	1.00	19–20	1.65	20	2.78	11	0.98	4	1.99	28	1.34	5	2.13	1	0.68	9–10	0.91	27–28	0.25	20–21	2.78	May	11
1906......	0.73	21–22	0.75	24	0.36	26–27	0.58	8–9	1.26	1–2	0.50	29–30	2.91	28	0.38	4	2.73	28–29	0.77	18	1.52	20–21	1.14	5–6	2.91	July	28
1907......	1.80	18–19	0.70	4–5	0.95	27–28	1.31	29–30	1.74	22–23	1.19	4–5	1.47	10–11	1.28	15–16	1.80	17–18	0.64	3	0.99	20	0.99	13–14	1.80	Jan. Sept.	18–19 17–18
1908......	1.22	12	1.27	18–19	1.32	26–27	0.80	6–7	1.90	28–29	0.56	13–14	0.52	16–17	4.34	11–12	1.33	27–28	0.36	23–24	1.06	25	0.65	16–17	4.34	Aug.	11–12
1909......	0.86	28–29	0.96	8–9	0.43	8	2.75	29	0.91	25–26	1.69	7–8	0.87	2	3.52	14–15	1.41	21–22	0.52	20	1.31	21–22	0.95	12–13	3.52	Aug.	14–15
1910......	0.71	17–18	0.52	26	0.24	19–20	0.97	30–My. 1	1.34	22–23	0.41	2, 4	0.54	11–12	1.81	23	1.41	4–5	1.10	3–4	0.83	26–27	0.71	28	1.81	Aug.	23
1911......	0.55	13	0.89	5–6	0.52	26–27	0.78	3–4	1.27	20–21	1.05	16–17	0.91	23	1.43	13	1.16	14–15	1.25	30–Oct. 1	1.51	11–12	0.60	30–31	1.51	Nov.	11–12
1912......	0.26	11–12	0.78	25–26	1.08	14–15	1.05	28–29	1.66	11–12	0.92	13–14	1.87	7–8	1.83	9–10	1.49	2	1.11	11	0.77	5–6	0.45	16–17	1.87	July	7–8
1913......	0.34	22–23	1.25	21	1.37	23–24	0.53	8–9	1.83	25–26	0.62	21	1.75	14	1.38	7–8	0.93	15–16	0.52	16–17	0.58	28–29	0.29	23	1.83	May	25–26
Greatest...	1.80		1.94		3.26		2.75		2.82		3.44		4.14		6.19		3.44		2.55		3.39		2.66		6.19		
Year....	1907	18–19	1876 1883	8–9 16	1884	25–26	1909	29	1873	1–2	1885	2–3	1878	25–26	1885	2–3	1875	9	1877	19–20	1883	5–6	1895	18–19	1885	Aug.	2–3

4. *Maximum precipitation in short periods.*—Table LXXXI contains the maximum amount of precipitation occurring in any 5-, 10-, 15-, and 30-minute period, and in any 1- and 2-hour period, for each month from 1903 to 1911, inclusive, during the time when the automatic gage can be secured from freezing conditions. There is a great variation in the entries of any one period, but the heaviest rates for each are as follows: 5 minutes, 0.64 inch, July 15, 1906; 10 minutes, 0.89 inch, on the same day; 15 minutes, 1.02 inch, August 23, 1910; 30 minutes, 1.34 inch, on the same day; 1 hour, 1.66 inch, on the same day (Table LXXVIII gives two heavier amounts within 1 hour, on June 19 and 23, 1871); 2 hours, 1.99 inch, August 11, 1908.

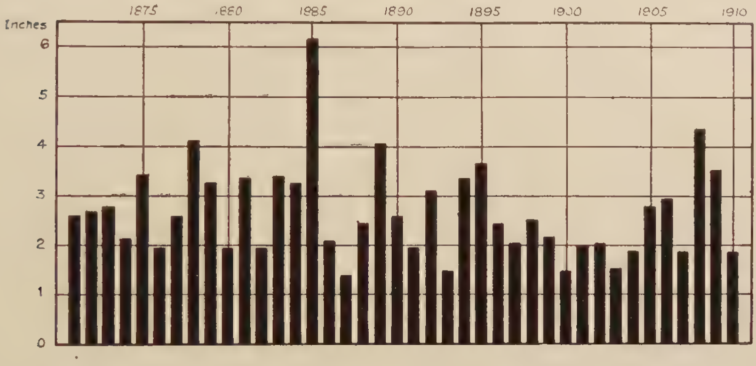


FIG. 40.—Heaviest precipitation in any twenty-four consecutive hours, 1871–1910 (see Table LXXX).

5. *Accumulated amounts of excessive rains.*—Table LXXXII gives in detail the accumulated amounts for successive periods of all storms in which the rate of fall was excessive, as determined by the limits established by the Weather Bureau, occurring during the exposure of the recording rain gage. Precipitation is called excessive if 0.25 inch occurs within 5 minutes, increasing at the rate of 0.05 inch for each period above the first, and can be determined for any period up to one hour, in steps of five minutes each, by simply adding 20 to the number of minutes. Thus, the rate at which precipitation becomes excessive is: for 10 minutes, 0.30 inch; for 35 minutes, 0.55 inch; for 60 minutes, 0.80 inch. Precipitation at the rate of 2.50 inches in twenty-four hours is also designated excessive.

Table LXXXIII summarizes the data on accumulated amounts of excessive rainfall, giving the averages of the amounts and the

TABLE LXXXI

Maximum Precipitation in Stated Periods, 1903–1911

	April						May					
Year	5 Min.	10 Min.	15 Min.	30 Min.	1 Hr.	2 Hrs.	5 Min.	10 Min.	15 Min.	30 Min.	1 Hr.	2 Hrs.
1903	0.22	0.25	0.26	0.26	0.29	0.49	0.11	0.14	0.15	0.18	0.22	0.29
1904	0.19	0.30	0.34	0.59	0.78	0.84	0.11	0.17	0.19	0.24	0.31	0.32
1905	0.13	0.15	0.17	0.24	0.34	0.50	0.36	0.60	0.82	1.13	1.25	1.30
1906	0.21	0.30	0.32	0.32	0.32	0.32	0.12	0.17	0.21	0.33	0.46	0.83
1907	0.07	0.13	0.15	0.20	0.31	0.46	0.12	0.16	0.20	0.26	0.39	0.47
1908	0.09	0.14	0.17	0.25	0.33	0.43	0.32	0.41	0.43	0.55	0.63	0.78
1909	0.22	0.29	0.37	0.47	0.65	1.12	0.07	0.12	0.15	0.22	0.28	0.31
1910	0.11	0.17	0.20	0.26	0.31	0.41	0.20	0.21	0.22	0.43	0.51	0.55
1911	0.14	0.17	0.19	0.21	0.21	0.27	0.31	0.39	0.45	0.51	0.55	0.61
	June						July					
1903	0.12	0.19	0.21	0.21	0.21	0.24	0.35	0.53	0.66	0.91	1.07	1.09
1904	0.10	0.12	0.12	0.12	0.12	0.12	0.24	0.31	0.41	0.42	0.50	0.60
1905	0.32	0.57	0.65	0.77	0.80	0.97	0.26	0.37	0.50	0.55	0.71	1.21
1906	0.19	0.26	0.31	0.34	0.35	0.37	0.64	0.89	1.01	1.26	1.64	1.69
1907	0.18	0.22	0.24	0.26	0.40	0.58	0.19	0.32	0.45	0.59	0.61	0.67
1908	0.24	0.26	0.28	0.36	0.41	0.42	0.15	0.20	0.20	0.29	0.33	0.37
1909	0.48	0.68	0.75	0.80	0.80	0.80	0.26	0.44	0.67	0.77	0.86	0.87
1910	0.08	0.13	0.14	0.15	0.16	0.32	0.20	0.36	0.37	0.42	0.43	0.43
1911	0.09	0.10	0.14	0.19	0.29	0.36	0.28	0.33	0.37	0.37	0.40	0.57
	August						September					
1903	0.21	0.34	0.47	0.71	0.87	0.95	0.15	0.15	0.37	0.50	0.63	0.80
1904	0.15	0.23	0.27	0.30	......	......	0.30	0.38	0.40	0.57	0.83	0.98
1905	0.51	0.86	0.98	1.23	1.26	1.26	0.31	0.49	0.61	0.89	1.47	1.54
1906	0.12	0.13	0.13	0.14	0.14	0.35	0.09	0.14	0.19	0.31	0.41	0.72
1907	0.29	0.54	0.67	0.75	1.01	1.14	0.20	0.29	0.32	0.37	0.39	0.47
1908	0.61	0.67	0.75	1.05	1.39	1.99	0.19	0.22	0.24	0.24	0.32	0.47
1909	0.40	0.75	0.95	1.24	1.56	1.89	0.25	0.30	0.38	0.47	0.58	0.94
1910	0.44	0.79	1.02	1.34	1.66	1.77	0.20	0.29	0.37	0.50	0.65	0.72
1911	0.23	0.35	0.46	0.77	0.91	1.11	0.39	0.53	0.60	0.75	0.90	0.97
	October						November					
1903	0.17	0.22	0.26	0.35	0.40	0.40	......	......	......	......	......	......
1904	0.26	0.37	0.47	0.68	0.76	0.88	0.04	0.06	0.80	0.15	0.20	0.22
1905	0.16	0.30	0.36	0.40	0.42	0.47	0.05	0.08	0.11	0.17	0.28	0.42
1906	0.07	0.10	0.13	0.16	0.28	0.38	0.01†	0.01†	0.02†	0.03†	0.05†	0.09†
1907	No available record						0.05	0.09	0.11	0.18	0.31	0.50
1908	0.02	0.03	0.04	0.07	0.10	0.16	0.15	0.20	0.26	0.37	0.54	0.70
1909	0.04	0.07	0.08	0.10	0.15	0.27	0.07	0.11	0.14	0.22	0.31	0.53
1910	0.16	0.19	0.25	0.39	0.47	0.75	0.10	0.18	0.22	0.26	0.37	0.41
1911	*	0.40	0.41	0.43	0.64	0.82	No available record					

* Automatic gage out of order. † For 1st–15th, inclusive.

Table LXXXI gives the maximum precipitation in inches in any 5, 10, 15, and 30 minutes, andi n any 1 and 2 hours for the months from April to November, inclusive, 1903–11. The tipping-bucket ,or recording rain gage is not exposed during the cold months.

greatest falls for the various periods in each month. From the grand averages it will be seen that, ordinarily, excessive precipitation continues for a period of about 26 minutes, in a total fall of about 2 hours and 50 minutes in length and of about 0.94 inch in amount. At the rate of the tabulated averages, about 0.69 inch of the total fall occurs during the 26 minutes of excessive precipitation.

DURATION OF PRECIPITATION

The question, How long does the average rainstorm or snowstorm last? would probably bring as many different estimates as there were individuals attempting the answer, and the reply of each would be based entirely upon vague recollection of his own experiences. In order to determine the average length of time in which precipitation falls continuously in the rainstorms, snowstorms and mixed storms at Chicago, the records for 20 years, from 1891 to 1910, inclusive, were examined, and the intervals for the storms of each class calculated and the results averaged. Table LXXXIV gives a summary of this work. This table does not include all storms which occurred during the period, as beginnings and endings in the night have not always been entered in the records, because of the difficulty in determining the exact time. It is believed, however, that a sufficient number was found to secure a fairly accurate average length. The average duration of the snowstorm, 7.5 hours, is considerably longer than that of the rainstorm, 3.9 hours, while mixed storms of rain, snow, sleet, etc., 7.3 hours, continue almost as long as do snowstorms. This might be expected, as such storms occur chiefly in the colder seasons. The average duration of the storms of all classes combined is 4.9 hours.

The rainstorm of December, 6.9 hours, the mixed storm of February, 16.1 hours, and the snowstorm of March, 8.9 hours, are on the average the longest of their respective classes. May shows in the table 11.7 hours for snowstorms, but as only two such storms with an appreciable fall have occurred in May in Chicago during the past 40 years, the result is an accident rather than an average, and cannot be used in comparison. On the whole, it will be seen that the storms of November to March, inclusive, are much longer than those of the remaining months of the year, and as the frequency of occurrence is also greater during this time (p. 168), it is apparent that the summer and early autumn months constitute a period when fair weather predominates decidedly, notwithstanding the fact that the

TABLE LXXXII

Excessive Precipitation, Accumulated Amounts in Inches in 5-Minute Periods, 1897–1913

Year	Day	Duration		Total Amount Inches	Excessive Rate		Amount before Excessive Rate Began	Depth of Precipitation (in Inches) during Periods of Time as Indicated												
		From	To		Began	Ended		5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	35 Min.	40 Min.	45 Min.	50 Min.	60 Min.	80 Min.	100 Min.
April																				
1904	23	9:25 P.M.	11:35 P.M.	0.84	10:41 P.M.	11:25 P.M.	0.08	0.14	0.21	0.38	0.50	0.56	0.59	0.62	0.66	0.74	0.76	......	......	......
1906	28	2:23 P.M.	3:28 P.M.	0.32	3:12 P.M.	3:22 P.M.	0.01	0.18	0.30	......	......	......	......	......	......	......	......	......	......	......
1909	29	12:20 A.M.	6:30 A.M.	1.53	5:10 A.M.	5:25 A.M.	1.07	0.08	0.17	0.37	......	......	......	......	......	......	......	......	......	......
May																				
1902	24	7:20 P.M.	11:30 P.M.	1.26	8:40 P.M.	9:20 P.M.	0.05	0.09	0.15	0.23	0.31	0.49	0.75	0.98	1.04	1.08	......	......	......	......
1905	11	9:55 A.M.	1:00 P.M.	1.36	11:15 P.M.	11:50 P.M.	0.07	0.16	0.53	0.77	0.98	1.09	1.14	1.20	......	......	......	......	......	......
1908	28	4:45 A.M.	8:18 A.M.	0.80	6:14 A.M.	6:23 A.M.	0.11	0.14	0.41	......	......	......	......	......	......	......	......	......	......	......
	28	7:12 P.M.	10:11 P.M.	0.81	7:38 P.M.	7:58 P.M.	0.03	0.10	0.26	0.38	0.49	......	......	......	......	......	......	......	......	......
1911	21	2:55 P.M.	4:25 P.M.	0.58	3:00 P.M.	3:06 P.M.	0.01	0.30	0.32	......	......	......	......	......	......	......	......	......	......	......
	28	5:03 P.M.	9:37 P.M.	0.62	5:07 P.M.	5:27 P.M.	0.01	0.28	0.38	0.44	0.49	......	......	......	......	......	......	......	......	......
June																				
1901	5	4:43 P.M.	8:09 P.M.	0.92	5:22 P.M.	5:52 P.M.	T	0.29	0.46	0.63	0.70	0.79	0.88	......	......	......	......	......	......	......
1902	7	1:50 P.M.	6:15 P.M.	0.69	4:18 P.M.	4:50 P.M.	0.07	0.10	0.22	0.31	0.41	0.50	0.55	0.58	......	......	......	......	......	......
1905	4	4:04 A.M.	6:35 A.M.	0.98	4:11 A.M.	4:26 A.M.	T	0.26	0.52	0.65	......	......	......	......	......	......	......	......	......	......
	25	9:10 P.M.	10:45 P.M.	0.80	9:39 P.M.	9:59 P.M.	0.03	0.25	0.46	0.58	0.68	......	......	......	......	......	......	......	......	......
1909	22	6:23 P.M.	7:02 P.M.	0.80	6:24 P.M.	6:39 P.M.	0.01	0.48	0.68	0.75	......	......	......	......	......	......	......	......	......	......

JULY

1897.....	4	12:08 P.M.	1:00 P.M.	0.42	12:10 P.M.	12:25 P.M.	T	0.05	0.20	0.37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900.....	2	9:45 P.M.	D.N.	1.06	9:54 P.M.	10:08 P.M.	0.01	0.22	0.36	0.42	0.44	0.51	0.60	0.65	0.70	0.71	0.74	0.76	.....	.....
1901.....	1	1:32 P.M.	5:45 P.M.	1.56	3:14 P.M.	3:35 P.M.	0.40	0.29	0.57	0.77	0.98	1.04	1.07	.....	.....	.....	.....	.....	.....	.....
1902.....	23	12:53 P.M.	2:45 P.M.	0.64	1:25 P.M.	1:50 P.M.	0.02	0.06	0.21	0.36	0.45	0.51	0.55	.....	.....	.....	.....	.....	.....	.....
1903.....	9	9:10 P.M.	10:25 P.M.	1.09	9:22 P.M.	9:50 P.M.	0.04	0.10	0.27	0.62	0.70	0.84	0.91	0.94	0.99	1.02	1.06	.....	.....	.....
1905.....	7	12:44 P.M.	2:50 P.M.	0.54	1:30 P.M.	1:45 P.M.	0.01	0.17	0.34	0.43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	28	4:05 A.M.	8:28 A.M.	1.81	5:19 A.M.	5:35 A.M.	0.05	0.23	0.37	0.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	28	4:05 A.M.	8:28 A.M.	1.81	6:19 A.M.	6:44 A.M.	0.62	0.05	0.10	0.19	0.30	0.47	.....	.....	.....	.....	.....	.....	.....	.....
	28	4:05 A.M.	8:28 A.M.	1.81	7:40 A.M.	8:04 A.M.	1.28	0.06	0.19	0.40	0.47	0.53	.....	.....	.....	.....	.....	.....	.....	.....
1906.....	15	11:15 A.M.	1:00 P.M.	1.34	11:17 A.M.	11:47 A.M.	0.01	0.05	0.22	0.33	0.91	1.19	1.26	.....	.....	.....	.....	.....	.....	.....
	28	11:14 A.M.	12:45 P.M.	1.69	11:20 A.M.	12:25 P.M.	0.03	0.08	0.20	0.52	0.86	0.96	1.04	1.09	1.13	1.20	1.32	1.61	.....	.....
	28	2:00 P.M.	7:26 P.M.	1.22	4:41 P.M.	5:21 P.M.	0.09	0.11	0.36	0.42	0.48	0.53	0.60	0.72	0.80	.....	.....	.....	.....	.....
1907.....	11	6:50 A.M.	9:21 A.M.	0.61	7:09 A.M.	7:34 A.M.	0.06	0.05	0.13	0.31	0.42	0.55	.....	.....	.....	.....	.....	.....	.....	.....
	21–22	9:40 P.M.	1:25 A.M.	0.73	10:15 P.M.	10:45 P.M.	0.06	0.09	0.20	0.28	0.34	0.44	0.52	.....	.....	.....	.....	.....	.....	.....
1909.....	2	7:32 P.M.	8:58 P.M.	0.87	7:54 P.M.	8:12 P.M.	0.02	0.16	0.35	0.59	0.75	.....	.....	.....	.....	.....	.....	.....	.....	.....
1910.....	22	3:40 P.M.	4:32 P.M.	0.43	3:45 P.M.	3:56 P.M.	0.01	0.19	0.35	0.36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911.....	15	6:54 P.M.	7:20 P.M.	0.37	6:57 P.M.	7:09 P.M.	0.01	0.06	0.26	0.36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1912.....	7	1:14 P.M.	5:44 P.M.	1.82	1:46 P.M.	2:38 P.M.	0.04	0.07	0.22	0.32	0.42	0.54	0.68	0.80	0.94	1.04	1.11	1.16	.....	.....
1913.....	14	7:32 P.M.	8:45 P.M.	0.85	7:38 P.M.	8:18 P.M.	0.02	0.13	0.29	0.40	0.50	0.59	0.67	0.74	0.79	.....	.....	.....	.....	.....

AUGUST

1897.....	9	4:20 P.M.	4:55 P.M.	0.38	4:20 P.M.	4:40 P.M.	0.00	0.07	0.17	0.30	0.37	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900.....	17	1:06 P.M.	4:27 P.M.	0.86	3:58 P.M.	4:20 P.M.	0.25	0.13	0.22	0.44	0.58	0.61	.....	.....	.....	.....	.....	.....	.....	.....
1903.....	3–4	10:35 P.M.	1:30 A.M.	0.99	10:40 P.M.	11:15 P.M.	0.01	0.16	0.33	0.45	0.50	0.54	0.72	0.80	0.84	.....	.....	.....	.....	.....
1905.....	5	6:04 A.M.	6:55 A.M.	1.26	6:06 A.M.	6:31 A.M.	T	0.51	0.86	0.98	1.11	1.20	.....	.....	.....	.....	.....	.....	.....	.....
	18	4:27 P.M.	5:45 P.M.	0.66	5:00 P.M.	5:25 P.M.	0.10	0.06	0.17	0.29	0.45	0.54	.....	.....	.....	.....	.....	.....	.....	.....
1907.....	16	12:52 A.M.	3:52 A.M.	1.16	1:01 A.M.	1:56 A.M.	0.01	0.08	0.08	0.16	0.32	0.42	0.53	0.66	0.81	0.87	0.92	1.00	.....	.....
	19	5:46 P.M.	11:55 P.M.	1.04	5:46 P.M.	6:16 P.M.	0.01	0.12	0.30	0.49	0.65	0.70	0.75	.....	.....	.....	.....	.....	.....	.....
	26–27	8:10 P.M.	1:06 A.M.	0.97	12:23 A.M.	12:40 A.M.	0.24	0.15	0.38	0.64	0.72	.....	.....	.....	.....	.....	.....	.....	.....	.....
1908.....	11–12	8:40 P.M.	3:55 A.M.	3.30	9:39 P.M.	11:09 P.M.	0.05	0.30	0.57	0.74	0.94	1.03	1.04	1.05	1.06	1.06	1.08	1.39	1.70	1.98
	11–12	8:40 P.M.	3:55 A.M.	3.30	11:51 P.M.	12:13 A.M.	2.06	0.07	0.27	0.48	0.53	0.58	.....	.....	.....	.....	.....	.....	.....	.....
	12	2:25 P.M.	5:30 P.M.	0.94	3:00 P.M.	3:18 P.M.	0.10	0.20	0.40	0.51	0.56	.....	.....	.....	.....	.....	.....	.....	.....	.....
	15	6:18 P.M.	8:30 P.M.	0.80	6:55 P.M.	7:04 P.M.	0.04	0.60	0.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1909.....	14	3:00 A.M.	8:57 A.M.	3.44	5:08 A.M.	5:43 A.M.	0.25	0.21	0.60	0.78	0.94	1.08	1.18	1.33	.....	.....	.....	.....	.....	.....
	14	3:00 A.M.	8:57 A.M.	3.44	6:58 A.M.	8:00 A.M.	1.79	0.09	0.21	0.50	0.92	1.11	1.20	1.26	1.29	1.38	1.41	1.53	1.64	.....
	27	12:57 P.M.	2:50 P.M.	1.22	1:08 P.M.	1:48 P.M.	0.19	0.11	0.28	0.51	0.61	0.64	0.78	0.92	0.99	.....	.....	.....	.....	.....
1910.....	23	2:05 A.M.	5:15 A.M.	1.81	2:06 A.M.	2:51 A.M.	T	0.32	0.71	1.02	1.15	1.23	1.34	1.46	1.55	1.60	.....	.....	.....	.....
1911.....	13	10:59 A.M.	11:53 A.M.	0.91	11:02 A.M.	11:43 A.M.	0.01	0.07	0.30	0.45	0.55	0.65	0.72	0.82	0.88	.....	.....	.....	.....	.....
1912.....	8	2:19 P.M.	4:03 P.M.	0.50	2:22 P.M.	2:37 P.M.	0.01	0.31	0.36	0.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	9	5:42 P.M.	8:34 P.M.	1.12	6:02 P.M.	6:42 P.M.	0.02	0.06	0.20	0.29	0.36	0.59	0.79	0.96	1.01	.....	.....	.....	.....	.....
	10	11:30 A.M.	12:06 P.M.	0.39	11:36 A.M.	11:50 A.M.	0.01	0.09	0.19	0.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913.....	7	10:16 P.M.	10:42 P.M.	0.38	10:21 P.M.	10:28 P.M.	0.01	0.31	0.37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	7–8	10:51 P.M.	1:15 A.M.	0.98	11:24 P.M.	11:39 P.M.	0.08	0.12	0.42	0.56	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	18	1:14 P.M.	2:18 P.M.	0.75	1:31 P.M.	1:47 P.M.	0.02	.....	0.49	0.63	0.67	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE LXXXII—*Continued*

SEPTEMBER

Year	Day	Duration		Total Amount Inches	Excessive Rate		Amount before Excessive Rate Began	Depth of Precipitation (in Inches) during Periods of Time as Indicated												
		From	To		Began	Ended		5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	35 Min.	40 Min.	45 Min.	50 Min.	60 Min.	80 Min.	100 Min.
1904.....	18	2:15 A.M.	5.45 A.M.	1.25	2:29 A.M.	3:00 A.M.	0.01	0.25	0.38	0.40	0.46	0.54	0.57	0.61	......	......	......	......	......	......
1905.....	1	6:45 P.M.	10:15 P.M.	1.56	8:23 P.M.	9:26 P.M.	0.03	0.15	0.30	0.49	0.65	0.81	0.89	0.97	1.08	1.21	1.28	1.47	......	......
	16	1:48 P.M.	2:30 P.M.	0.44	1:56 P.M.	2:05 P.M.	0.01	0.21	0.44	......	......	......	......	......	......	......	......	......	......	......
	18	4:10 A.M.	6:10 A.M.	0.87	5:13 A.M.	5:38 A.M.	0.02	0.19	0.47	0.60	0.61	0.82	......	......	......	......	......	......	......	......
1909.....	14	5:08 P.M.	8:20 P.M.	1.08	5:14 P.M.	5:35 P.M.	0.01	0.08	0.27	0.44	0.46	......	......	......	......	......	......	......	......	......
1910.....	12	4:30 P.M.	7:45 P.M.	0.81	4:53 P.M.	5:11 P.M.	0.01	0.12	0.29	0.37	0.45	......	......	......	......	......	......	......	......	......
1911.....	18	1:28 A.M.	4:00 A.M.	0.99	1:31 A.M.	2:01 A.M.	0.01	0.35	0.53	0.60	0.64	0.70	0.75	......	......	......	......	......	......	......
1912.....	2	2:28 P.M.	3:54 P.M.	1.47	2:39 P.M.	3:19 P.M.	0.03	0.12	0.40	0.57	0.70	0.84	0.90	1.21	1.41	......	......	......	......	......

OCTOBER

Year	Day	From	To	Total Amount Inches	Began	Ended	Amount before Excessive Rate Began	5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	35 Min.	40 Min.	45 Min.	50 Min.	60 Min.	80 Min.	100 Min.
1904.....	4-5	11:50 P.M.	5:05 A.M.	0.97	12:51 A.M.	1.20 A.M.	0.01	0.08	0.17	0.24	0.35	0.59	0.67	......	......	......	......	......	......	......
1905.....	17	1:40 A.M.	5:00 A.M.	0.48	3:51 A.M.	4:06 A.M.	0.06	0.12	0.26	0.36	......	......	......	......	......	......	......	......	......	......
1911.....	16	2:40 P.M.	4:25 P.M.	0.45	3:01 P.M.	3:11 P.M.	0.01	0.23	0.40	......	......	......	......	......	......	......	......	......	......	......

Table LXXXII contains a list of all dates on which excessive precipitation has occurred from 1897 to 1913. The rates at which precipitation becomes excessive are given in the text. This table shows the year, month, and day on which excessive precipitation occurred, the duration of the entire rain period, the total amount of precipitation, the beginning and ending of the excessive rate, the amount before excessive precipitation began, and the accumulated depth in periods of 5 minutes. D.N. signifies time unknown, but occurred during the night.

TABLE LXXXIII

SUMMARY OF EXCESSIVE PRECIPITATION IN INCHES IN CUMULATIVE 5-MINUTE PERIODS

	Excessive Rains				Excessive Periods												
	Number	Duration of Precipitation	Amounts	Duration of Excessive Rate	5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	35 Min.	40 Min.	45 Min.	50 Min.	60 Min.	80 Min.	100 Min.
					Averages												
			in.	min.													
April........	3	3h 22m	0.90	23	0.13	0.23	0.38	0.50	0.56	0.59	0.62	0.66	0.74	0.76	....	....	....
May........	4	2 27	1.06	26	0.12	0.34	0.46	0.59	0.79	0.94	1.09	1.04	1.08	....	....	....	....
June........	5	2 31	0.84	22	0.28	0.47	0.58	0.60	0.64	0.72	0.58	....	....	....	....	....	....
July........	16	2 6	0.88	25	0.12	0.26	0.43	0.59	0.69	0.82	0.85	0.90	0.98	1.04	1.18	1.67	1.98
August.......	16	2 55	1.18	34	0.20	0.39	0.55	0.69	0.81	0.94	1.07	1.09	1.23	1.14	1.31	....	....
September....	6	2 12	1.00	28	0.17	0.36	0.46	0.53	0.72	0.73	0.79	1.08	1.21	1.28	1.47	....	....
October......	2	4 18	0.72	22	0.10	0.22	0.30	0.35	0.59	0.67	....	....	....	....	....	....	....
Average......	......	2 50	0.94	26	0.16	0.32	0.45	0.55	0.69	0.77	0.83	0.95	0.75	1.06	1.32	1.67	1.98
					Greatest												
			in.														
April........	......	6h 10m	1.53	0h 44m	0.18	0.30	0.38	0.50	0.56	0.59	0.62	0.66	0.74	0.76	....	....	....
May........	......	4 00	1.36	0 40	0.16	0.53	0.77	0.98	1.09	1.14	1.20	1.04	1.08	....	....	....	....
June........	......	4 25	0.98	0 32	0.48	0.68	0.75	0.70	0.79	0.88	0.58	....	....	....	....	....	....
July........	......	5 26	1.81	0 40	0.29	0.57	0.77	0.98	1.19	1.26	1.09	1.13	1.20	1.32	1.61	1.70	1.98
August.......	......	6 09	3.44	1 30	0.60	0.86	1.02	1.15	1.23	1.34	1.46	1.55	1.60	1.41	1.53	....	....
September....	......	3 30	1.56	1 03	0.25	0.47	0.60	0.65	0.82	0.89	0.97	1.08	1.21	1.28	1.47	....	....
October......	......	5 15	0.97	0 29	0.12	0.26	0.36	0.35	0.59	0.67	....	....	....	....	....	....	....
Greatest.....	......	6 10	3.44	1 30	0.60	0.86	1.02	1.15	1.23	1.34	1.46	1.55	1.60	1.41	1.61	1.70	1.98
Year.......	......	....	....	....	1908	1905	1910	1910	1910	1910	1910	1910	1910	1909	1906	1908	1908
Month.....	......	....	....	....	August	August	August	August	August	August	August	August	August	August	July	August	August
Day.......	......	....	....	....	15	5	23	23	23	23	23	23	23	14	28	11	11
Hour of beginning...	......	....	....	....	6:55 P.M.	6:06 A.M.	2:06 A.M.	2:06 A.M.	2:06 A.M.	2:06 A.M.	2:06 A.M.	2:06 A.M.	2:06 A.M.	6:58 A.M.	11:20 A.M.	9:39 P.M.	9:39 P.M.

Table LXXXIII shows the average rate of excessive precipitation and the greatest rate of excessive precipitation in cumulative 5-minute periods, April to October, inclusive, 1897–1911. It should be noted, however, in that part of the table containing the averages, that as the length of the 5-minute periods increases, the figures represent less and less the true average rates for the whole number of excessive rains, as shown in the column headed "number." This is because all the excessive rains do not extend over the entire period of 100 minutes, and for some of the longer cumulative periods the figures represent the averages for only a few excessive rains, while for the period of 100 minutes the 1.98 inches representing same is not an average at all, there being but one storm having excessive rain which continued for that length of time. Under that portion of the table headed "Greatest" the various amounts represent the highest for that period without regard to whether all occurred in the same storm or not.

TABLE LXXXIV

LENGTH OF PRECIPITATION

		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rainstorms	Number of storms	60	58	116	208	315	281	229	191	234	164	143	79	2,078
	Average duration (hrs.)	4.8	4.0	5.1	4.0	3.0	2.1	2.2	2.5	3.3	3.9	5.1	6.9	3.9
	Number less than 1 hr.	21	13	26	54	95	142	93	69	74	43	30	13	673
	Number over 12 hrs.	5	6	16	15	13	8	3	4	14	10	16	15	125
	Longest (hrs.)	54.5	25.1	33.9	38.5	33.0	22.7	17.2	22.5	23.7	52.6	29.7	30.5	54.5
Snowstorms	Number of storms	131	106	55	17	2	0	0	0	0	2	34	94	441
	Average duration (hrs.)	7.9	8.6	8.9	8.1	11.7	0	0	0	0	0.4	6.3	8.0	7.5
	Number less than 1 hr.	14	13	4	1	0	0	0	0	0	2	3	8	45
	Number over 12 hrs.	28	24	14	3	1	0	0	0	0	0	4	22	96
	Longest (hrs.)	35.2	35.2	39.0	29.3	13.0	0	0	0	0	0.8	16.0	28.1	39.0
Mixed storms—Rain and snow, etc.	Number of storms	28	24	35	26	5	7	2	3	0	5	27	36	198
	Average duration (hrs.)	11.2	16.1	8.9	7.6	5.3	1.6	1.2	1.6	0	5.1	10.7	11.0	7.3
	Number less than 1 hr.	1	2	5	5	0	2	1	1	0	1	1	1	20
	Number over 12 hrs.	7	14	6	5	0	0	0	0	0	0	10	13	55
	Longest (hrs.)	52.7	71.7	50.7	43.1	7.7	2.6	2.1	2.8	0	10.1	31.3	45.3	71.7
All storms	Number of storms	219	188	206	251	322	288	231	194	234	171	204	209	2,717
	Average duration (hrs.)	7.5	8.1	6.8	4.7	3.1	2.1	2.2	2.5	3.3	3.9	6.0	8.1	4.9
	Number less than 1 hr.	36	28	35	60	95	144	94	70	74	46	34	22	738
	Number over 12 hrs.	40	44	36	23	14	8	3	4	14	10	30	50	276
	Longest (hrs.)	54.5	71.7	50.7	43.1	33.0	22.7	17.2	22.5	23.7	52.6	31.3	45.3	71.7

Table LXXXIV includes only storms from 1891 to 1910, in which 0.01 inch or more of rain or (melted) snow, sleet, etc., fell continuously, and only those for which the times of beginning and ending were recorded definitely, or could be closely approximated from the official records.

amount of precipitation is then greater than it is during the winter. In individual records, January shows a rainstorm lasting 54.5 hours, while the longest record for July is 17.2 hours. Snowstorms of between 35 and 40 hours have occurred in January, February, and March, and a mixed storm of 71.7 hours in length occurred in February. The mixed storms of the winter are really the longest of any kind or season, as they usually occur in connection with widespread disturbances which give during their passage sleet and rain on the eastern side, turning to snow as the center of the area passes the point of observation.

Out of the total number of storms recorded in the table, 738, or about 25 per cent, lasted less than 1 hour, and 276, or about 10 per cent, lasted more than 12 hours; of the rainstorms, 673, or about 33 per cent, lasted less than 1 hour, and 125, or about 6 per cent, more than 12 hours; of the snowstorms, 45, or about 10 per cent, lasted less than 1 hour, and 96, or about 20 per cent, more than 12 hours; of mixed storms, 20, or about 10 per cent, lasted less than 1 hour, and 55, or about 25 per cent, more than 12 hours. It is apparent, therefore, that the average duration of both snowstorms and mixed storms is considerably greater than that of rainstorms.

RAINSTORMS AND SNOWSTORMS OF LONG DURATION

It quite often happens that during the passage of a general disturbance across the region in which Chicago is situated there occur a number of separate falls of rain or snow which must, nevertheless, be considered as a part of the whole storm, and they usually happen with only short intervals of time between. Table LXXXV contains a list of such rainstorms and snowstorms from 1881 to 1910. The dates and duration in days of the various disturbances are given, together with the number of hours of actual precipitation, excluding any intervals between the periods of fall. The data in the table are entirely apart from those previously given on wet spells and excessive precipitation, although in some cases the same dates will be found in all sets. In Table LXXXV the precipitation fell without interruption of more than an hour or two, while in the table of consecutive days with precipitation (p. 173, Table LXXIV), the interval may have been more than twenty-four hours. For instance, if rain on one day ended before noon, and on the following day began again after noon, both days would be included in a series of consecutive days with rainfall, and yet the precipitation recorded might be in

connection with two separate storms following closely the one after the other. Again, the amount of precipitation has no relation to the length of the entire storm, and the period, however long, is not necessarily one with excessive precipitation, or a wet spell, as the

TABLE LXXXV

Examples of Rainstorms and Snowstorms of Long Duration, 1881–1910

Year	Period	Hours of Actual Precipitation	Amount Inches	Year	Period	Hours of Actual Precipitation	Amount Inches
1881.....	October 16–18	47	0.95	1893....	April 19–22	84	0.56
	December 19–22	58	1.44	1895....	December 18–21	76	5.48
1882.....	April 9–11	42	1.49	1897....	January 1–5	78	2.49
	May 11–13	41	0.76	1899....	October 26–28	58	1.60
	August 30–September 1	37	0.32	1900....	January 17–19	53	0.90
	December 19–21	47	1.20		March 28–30	39	0.51
1883.....	January 15–17	46	0.64	1901....	March 13–15	63	0.26
1884.....	December 5–7	34	0.97		March 20–21	34	0.33
1885.....	September 7–10	52	1.91		December 3–5	42	0.12
	December 12–14	42	0.88	1902....	February 27–March 2	78	1.11
1886.....	March 30–April 1	46	0.78	1905....	April 25–27	40	0.55
	November 16–18	44	0.85	1906....	February 4–6	50	0.20
1887.....	February 5–7	43	0.86	1910....	January 12–14	54	1.30
	December 9–11	50	1.12				

Table LXXXV contains some examples of rainstorms and snowstorms of long duration.

term is used in Table LXXVI. The long period of 84 hours in April, 1893, was of only light precipitation, the total amount being but 0.56 inch; while in the period of 76 hours in December, 1895, the amount for the storm was 5.48 inches.

PERIODS OF DROUTH

In Tables LXXXVI and LXXXVII are listed all periods of 15 days or more in which an inappreciable amount of rain—that is, less than 0.01 inch—and in which no rain at all fell, respectively. The longest period without precipitation of any kind covered the first three weeks of February, 1877, and was 21 days in length. During the remainder of that month only 0.06 inch fell, which makes it the driest month in the history of Chicago's weather. Only 8 other periods of 15 days or more without precipitation have occurred since the beginning of the official observations, while there have been only 26 periods of 15 days or more altogether in which not more than a "trace" of precipitation occurred. The longest and one of the second longest of these, however, fell close together in the summer of 1893, during the time of the Columbian Exposition in Chicago, in one of the most remarkable periods of drouth for this locality. From

July 17 to August 10 of that year, a period of 25 days, only an unmeasurably small amount of rain fell, and the same was true of the 26 days following from August 17 to September 11. Between these two periods 0.18 inch occurred, 0.02 inch on the 11th and 0.16 inch on the 16th, this amount being the total precipitation for that August.

TABLE LXXXVI

PERIODS OF DROUTH, 1871–1913

Days	Time	Year	Days	Time	Year
26..........	August 17–September 11	1893	20.........	February 26–March 18	1910
25..........	July 17–August 10	1893	19.........	December 21, 1897–January 8	1898
25..........	August 13–September 6	1899	18.........	August 14–31	1879
25..........	December 15, 1899–January 8	1900	18.........	August 29–September 15	1897
24..........	June 26–July 19	1898	17.........	November 3–19	1907
23..........	October 7–29	1872	17.........	September 22–October 9	1909
22..........	March 29–April 19	1887	16.........	September 28–October 13	1886
21..........	October 16–November 5	1895	16.........	October 24–November 8	1887
21..........	December 30, 1901–January 19	1902	16.........	October 27–November 11	1893
20..........	October 18–November 6	1891	16.........	November 14–29	1894
20..........	July 21–August 9	1894	16.........	February 4–19	1910
20..........	September 21–October 10	1897	16.........	June 21–July 6	1912
20..........	October 12–31	1897	15.........	February 1–15	1913

Table LXXXVI contains a list of dry periods of 15 days or more at Chicago, from 1871 to 1913, in which only a trace of rain fell, arranged in order of length.

From the beginning date of this dry spell on July 17 to September 12, on which day 0.03 inch occurred, a period of 58 days, the total precipitation was but 0.21 inch, and the time is the most prolonged period of drouth ever experienced in Chicago. Moreover, the rain which fell on September 13 was light, being only 0.22 inch, and it

TABLE LXXXVII

PERIODS OF DROUTH, 1871–1913

Days	Time	Year	Days	Time	Year
21..........	February 1–21	1877	16.........	May 15–30	1881
19..........	October 12–30	1897	16.........	August 7–September 1	1889
18..........	July 22–August 8	1908	15.........	August 31–September 14	1871
16..........	February 4–19	1873	15.........	October 7–21	1900
16..........	October 1–16	1896			

Table LXXXVII contains a list of dry periods of 15 days or more at Chicago, from 1871 to 1913, in which *no rain whatever* fell, arranged in order of length.

was not until after the 17th that the situation was relieved by sufficient rainfall. Another period, almost as remarkable, was that of 57 days, from November 6, 1872, to January 1, 1873, during which time the total fall was only 0.36 inch. These periods, together with all others of 2 weeks or more in which 0.10 inch or less occurred for each 2 weeks of time, are shown in Table LXXXVIII, which

TABLE LXXXVIII

DRY SPELLS OF TWO WEEKS OR LONGER, 1871–1911

Year	January	February	March	April	May	June	July	August	September	October	November	December	Year
1871								5–22, 31 .09–18, .00	–14, 17 –15, .11	–8* –22		25–	1871
1872	–18 .15–25	21 .03	–6 –15							7–29 T–23	6–	– – – – – .36–57	1872
1873	–1	4–25 .10–22			31 .13	–21 –22						14– .05–21	1873
1874	–3					10 .20	–6, 8 –27, .15	–4 –28		8–21 .05–14		17– .12–20	1874
1875	–5											9–23 .09–15	1875
1876				14 .06	–2 –19				22 .09	–12 –21			1876
1877	17 .17	–28 –43			21 .07	–6 –17	6–24 .03–19						1877
1878												23–	1878
1879	–14 .07–23			14 .01	–2 –19			14–31 T–18		18 .06	–1 –15		1879
1880												21–	1880
1881	–12 .09–23				15–30 .00–16		23 .03	–5, 19 –14, .05	–2 –15			23– .04–15	1881
1882	–6, 27 .09	–17 –22							3–20 .04–18				1882
1883			7–25 .07–19				28 .16	–26 –30			27 .10	–15 –19	1883
1884					14–31 .10–18		9–22 .02–14						1884

1885		16 -5 .05 -18											1885
1886					15 -4, .07 -21,	17 -8 .09 -22			28 -13 T -16				1886
1887			7-26, 29 -19 .08-20, T -22				10 -10 .10 -32			24 -8 T -16			1887
1888						2-20 .03-19		18 -7 .09 -21					1888
1889	21 -9 .08 -20		9-28 .01-20					14 -3 .05 -21					1889
1890							25 -16 .07 -23				18 -1, .04 -14,	6-30 10-25	1890
1891	3-20 .04-18						19 -8 .05 -21		4 -3, .12 -30,	8 -6 .12 -30			1891
1892									14 -14 .14 -31				1892
1893			25 -9 .02 -16				17 - - - - - -12 .21-58					31-	1893
1894	-14 .01-15				24 -14 .02 -22		1-19, 21 -9, .07-19, T -20,	15 -2, .07 -19,	23 -18 .11 -26		14 -9 .09 -26		1894
1895			5-30 .09-26	9 -4 .08 -26					17 -5, .05 -19,	12 -5 .01 -25			1895
1896					3-16 .04-14	29 -13 .06 -15				1-16 .00-16	27 -31 .16 -35		1896
1897								15 -15, .13 -32,	21 -31 .18 -41			18-	1897
1898	-8 .02-22					26 -19 T -24							1898
1899	29 -20 .07 -23		31 - - - - - -1 .14-32					12 -6, .04 -26,	29 -14 .04 -16			15- T-25	1899
1900	-8, 20 -3 T -15			18 -1 ,02 -14			25 -11 .03 -18		30 -21 .07 -22			8-29 .10-22	1900

TABLE LXXXVIII—*Continued*

	January	February	March	April	May	June	July	August	September	October	November	December	
1901		18 .02	-7 -18	1–14 .09–14			3–17, 30 .08–15	-17, 23 .03–19, 04	-8, 16 -17, .01	-8, 14 -23, .08	-2 -20	26–	1901
1902	-19 .01–25			7–21 .01–15				21 .05	-8 -19				1902
1903					1–21 .03–21					17 .15	-25 -40		1903
1904						5–19 .03–15		26 .03	-12 -18	13 .10–26	-7, 11 .01	-1 -21	1904
1905		26 .01	-12 -15						19 .02	-9 -21		4–19 .01–16	1905
1906					9–26 .08–18								1906
1907										16–31 .02–16	3–19 T–17		1907
1908							18 .05	-10, 30 -24, .01	-18 -20	9–22, 28 T–14, .09	-21 -25		1908
1909									23 T	-9 -17			1909
1910		3–19, 27 .01–17, T	-18, 21 -20, .05	-3 -14		5 .14	-10, 23 -36 .12	-14 -23		7–20 .03–14	5–19 .06–15		1910
1911	14 .05	-4, 26 -22 .04	-11 -14										1911

Table LXXXVIII gives all periods from 1871 to 1911, inclusive, of two weeks or longer, during which the amount of precipitation was less than 0.10 inch for each two weeks. The limiting dates of each period are shown in light-faced type. The first bold-faced figures give the amount of precipitation in inches, and the second, the duration of the dry spell in days. Such spells occur only when dry weather prevails also over a large expanse of the surrounding country, and in most instances are either immediately preceded or followed by abundant precipitation.

* No record from 8th to 15th, inclusive.

gives the limiting dates, the number of days of each dry spell and the amount of precipitation, throughout the official period. Such periods are limited to no particular time of the year, but are most numerous in the late summer and autumn. Of the number listed in the table, 43 occurred or began during the first six months of the year, and the remainder, 78, during the last six months. No year has been entirely free from these periods of dryness, but there are a number of instances in which none occurred during the growing season. The years 1894 and 1901 were marked by repeated spells, especially after July 1, there being 7 in each of these years. Both were dry years throughout, 1901 being the year of least precipitation in the official record, and with the record-breaking temperature of 103° in July. A drouth period of more than ordinary interest to Chicagoans is that covering 22 days, from September 17 to October 8, 1871, just prior to the Great Fire. But 0.11 inch of rain fell during the 22 days mentioned, and, indeed, for more than two and a half months previous there had been comparatively little rainfall; and it is undoubtedly because of the extreme dryness of the buildings, due to the drouth, that the fire spread so rapidly. The daily amounts of rainfall from July 1, 1871, to the time of the fire, are given separately in Table LXXXIX.

TABLE LXXXIX

DROUTH PRECEDING THE CHICAGO FIRE OF 1871

(Precipitation, in inches, by days, with departures from the normals)

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
July	....	....	1.57	...	....	0.15	....	....	....	0.23	....	....	....	....	....	0.01	....
August	....	...	...	0.73	....	....	T	T	....	....	0.09	....	....	....	....	....	....
September	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0.53	0.10	....
October*	....	....	...	....	....	....	....	*	....	....	....	....	....	....	....	....	....

Month	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total	Departure
July	....	0.34	0.01	....	T	....	....	....	0.20	....	....	....	0.01	....	2.52	−1.14
August	....	....	....	....	....	0.30	....	....	....	....	0.08	0.66	0.15	....	2.01	−0.92
September	....	....	....	....	....	....	....	....	....	....	0.11	....	....	....	0.74	−2.23
October*	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0*	−0.65*

* Data in October to and including the 8th day only.

T indicates "trace" of precipitation.

Table XC contains a statement of the number of periods of 10 days or more, by months, from 1871 to 1910, inclusive, with precipitation of less than 0.01 inch, the number totaling for the entire time 125, which would be an average occurrence of about 3 for each

year. The average duration is 13 days, and the longest on record entirely within a month was 23 days. The table was prepared

TABLE XC

Summary of Dry Spells in 40 Years, by Months, 1871–1910

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Period
Total number	11	6	5	6	6	6	18	14	15	20	7	11	125
Average duration (days)	12	15	13	13	12	11	12	13	12	14	12	12	13
Greatest duration (days)	19	21	18	19	16	13	19	19	15	23	17	17	23

Table XC contains a summary of the dry spells in 40 years, by months, 1871–1910, and is based upon periods of 10 consecutive days or more in which less than 0.01 inch of precipitation fell.

by months strictly, no overlapping dates being counted, and the data therefore cannot be compared with those of the preceding tables on this subject.

FREQUENCY OF PRECIPITATION, DAILY

The number of times on each day of the year that precipitation of measurable amounts has occurred is shown in Table XCI, for the period 1871 to 1910, inclusive, the data furnishing in some measure the probability of occurrence on any particular date. Some notable irregularities are apparent, however. It can scarcely be considered strange that precipitation has occurred 24 times on March 19, inasmuch as March is the month of greatest frequency (p. 168), and there are two other dates in March with records of more than 20 times; but that it should have occurred on March 13 but 8 times and on March 29 but 7 times, while the days before and after in both instances show at least twice the frequency, is remarkable. Other dates which show very few instances of precipitation are October 21, with the lowest record of 5 times, July 15, August 7, 8, 31, September 1, and December 15, with 6 times each. Scanning the table from the beginning to the end of the year, there appear to be short periods of from 3 to 5 days each on which the occurrence of precipitation is high, followed by similar intervals of low frequency, but there is not sufficient regularity to establish any rule of recurrence of either class. However, the table appears to furnish interesting and conclusive disproval of the belief, somewhat widely held, that storms are much more frequent during and immediately after the times of the equinoxes. The average occurrence on each date of the 5-day intervals from March 21 to 25, and September 21 to 25, 13.6

and 11.2, respectively, are in each case lower—and in March, considerably lower—than the average occurrence for the months in which the periods fall. On the other hand, the 5-day intervals from the 8th to the 12th in each of these two months show average occur-

TABLE XCI

FREQUENCY OF PRECIPITATION ON EACH DAY OF THE YEAR, 1871–1910

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1	11	14	19	14	18	16	10	16	6	15	11	15	
2	18	12	16	12	21	17	18	11	8	12	19	16	
3	15	18	14	13	20	16	19	10	15	8	9	17	
4	16	18	16	11	14	15	16	17	13	17	10	18	
5	9	17	14	16	15	15	15	13	13	13	16	16	
6	15	15	15	15	11	17	16	10	10	14	11	15	
7	11	14	15	12	14	18	14	6	12	13	16	17	
8	16	16	15	14	18	18	12	6	14	8	13	12	
9	13	14	14	18	15	15	18	12	16	8	17	10	
10	8	14	16	18	18	15	11	13	12	10	17	16	
11	16	16	19	17	16	11	8	13	13	14	17	13	
12	18	15	16	16	10	12	10	12	15	9	10	15	
13	19	14	8	19	18	17	8	11	12	13	11	18	
14	13	15	17	14	15	15	15	11	10	12	15	17	
15	21	15	17	21	14	18	6	15	12	11	13	6	
16	15	12	12	11	10	13	12	12	14	13	17	14	
17	11	14	11	12	16	10	13	7	7	11	17	18	
18	15	14	21	20	17	15	13	8	14	12	13	12	
19	13	16	24	17	17	9	11	13	12	11	14	14	
20	18	20	19	10	13	21	12	8	9	11	10	18	
21	18	10	13	16	15	16	13	13	6	5	13	18	
22	17	18	10	15	17	14	8	9	10	10	14	14	
23	20	16	13	12	15	14	7	13	14	8	11	15	
24	11	17	15	15	10	11	10	12	12	7	12	16	
25	12	16	17	17	15	17	16	13	14	14	15	19	
26	14	15	22	18	13	13	13	11	12	19	21	13	
27	15	11	14	18	14	19	12	12	11	14	15	12	
28	12	18	16	15	13	11	13	11	14	10	12	13	
29	10	4*	7	9	17	12	11	12	10	11	15	16	
30	15	......	18	12	13	11	8	9	11	15	13	14	
31	15	......	14	......	13	......	10	6	......	12	......	10	
Average	14.5	15.1	15.4	14.9	15.0	14.7	12.2	11.1	11.7	11.6	13.9	14.7	125.1
Greatest	21	20	24	21	21	21	19	17	16	19	21	19	24
Least	8	10	7	9	10	9	6	6	6	5	9	6	5
Average percentage	36	38	38	37	38	37	30	28	29	29	35	37	31

Table XCI shows the number of times that rain or melted snow to the depth of 0.01 inch or more has fallen on each day of the year.

* For 9 years.

rences higher than those of the respective months; and in similar manner many other 5-day intervals throughout the year can be noted which have higher average occurrences than do the equinoctial periods.

NORMAL PRECIPITATION, ANNUAL, MONTHLY, AND DAILY

A table of mean daily precipitation for the 42 years of the official period would present irregularities even more pronounced than do the data in Table XCI. Such mean values for the city of Baltimore are given in the publications of the Maryland Weather Service,

Volume II, and the daily amounts are very irregular. For instance, the mean daily precipitation for August 26, 27, and 28 is 0.15, 1.03, and 0.14 inch, respectively, and other instances of wide variation are shown. During a period of from 30 to 40 years heavy rains may have occcurred several times on certain dates, while on the days both before and after the rainfalls may have been few and the amounts

TABLE XCII

DAILY NORMAL PRECIPITATION, IN INCHES, 1871–1906

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1	0.06	0.05	0.08	0.08	0.10	0.13	0.12	0.12	0.09	0.10	0.09	0.06	
2	.06	.06	.08	.08	.10	.14	.13	.10	.08	.09	.09	.06	
3	.06	.07	.08	.08	.11	.13	.13	.08	.08	.08	.09	.06	
4	.06	.08	.08	.08	.12	.13	.14	.08	.10	.08	.10	.06	
5	.06	.08	.08	.08	.14	.13	.14	.08	.10	.08	.10	.06	
6	.06	.09	.08	.09	.14	.12	.15	.07	.11	.08	.10	.07	
7	.06	.09	.08	.09	.13	.12	.14	.06	.12	.08	.10	.07	
8	.06	.09	.07	.10	.13	.12	.12	.06	.12	.08	.11	.08	
9	.06	.09	.07	.10	.13	.12	.12	.06	.12	.08	.11	.08	
10	.07	.09	.07	.10	.12	.12	.12	.06	.12	.08	.09	.07	
11	.07	.09	.07	.10	.11	.12	.11	.06	.12	.08	.09	.07	
12	.07	.09	.07	.11	.11	.11	.10	.07	.12	.08	.09	.07	
13	.07	.09	.07	.11	.11	.11	.09	.07	.12	.08	.09	.07	
14	.08	.08	.08	.11	.10	.11	.10	.08	.11	.09	.08	.08	
15	.08	.08	.08	.11	.08	.11	.10	.08	.10	.09	.08	.08	
16	.09	.08	.08	.10	.07	.12	.10	.09	.10	.09	.08	.07	
17	.09	.07	.07	.09	.07	.12	.09	.09	.10	.08	.08	.07	
18	.08	.07	.07	.09	.07	.13	.10	.10	.09	.08	.08	.07	
19	.08	.07	.07	.10	.07	.13	.09	.12	.09	.08	.07	.07	
20	.08	.07	.08	.10	.09	.13	.09	.12	.09	.08	.07	.07	
21	.08	.07	.09	.10	.09	.13	.10	.12	.09	.08	.08	.07	
22	.07	.07	.09	.10	.10	.13	.11	.12	.09	.08	.08	.07	
23	.07	.07	.10	.10	.10	.12	.13	.13	.09	.08	.08	.06	
24	.05	.07	.09	.09	.11	.12	.13	.13	.09	.07	.07	.06	
25	.05	.07	.09	.09	.11	.12	.12	.13	.09	.07	.07	.06	
26	.05	.07	.10	.10	.12	.11	.12	.12	.09	.08	.06	.06	
27	.04	.08	.10	.10	.12	.11	.12	.11	.10	.08	.06	.06	
28	.04	.08	.10	.10	.13	.12	.13	.10	.10	.09	.07	.06	
29	.05	......	.10	.10	.13	.13	.13	.09	.10	.09	.07	.06	
30	.05	......	.09	.10	.13	.12	.14	.09	.10	.08	.07	.06	
31	.05	......	.09	......	.13	......	.13	.09	......	.09	......	......	
Sums	2.00	2.16	2.55	2.88	3.37	3.66	3.64	2.88	3.02	2.55	2.50	2.07	Annual 33.28

Table XCII contains the daily normal precipitation based upon records from 1871 to 1906. The daily values were obtained by using the means of eleven successive dates—that is, beginning with January 1–11, the mean precipitation was taken and entered against January 6; then taking January 2–12, the mean precipitation was entered against January 7; and in this way the normals were secured for each day of the year. This process gives values which approximate very closely the mean curve resulting from a much longer period of actual observations.

light. Even the monthly precipitation shows a great variation, and the annual amounts indicate an irregularity from year to year. Yet it is important to have some means by which comparisons may be made, not only with regard to the precipitation of years and months, but with regard to the daily falls, as well. For this purpose the Weather Bureau has used the records of daily rainfall and snowfall from 1871 to 1906, inclusive, in calculating and smoothing out the

daily normals of precipitation throughout the year, and these normals, together with the monthly and annual values, are given in Table XCII. In order that the daily means of precipitation should approach even more closely these smoothed-out normals, the period of observations would necessarily have to extend over a series of years of perhaps twenty times the length of the official record, and the reason for the more or less arbitrary values is therefore obvious.

EXAMPLES OF DEPARTURES FROM DAILY NORMAL PRECIPITATION, SELECTED YEARS

Tables XCIII, XCIV, and XCV have been prepared in order to illustrate the use of the daily normals of precipitation in determining the departures throughout the year, from day to day, and from

TABLE XCIII

DAILY DEPARTURE IN INCHES OF PRECIPITATION FROM NORMAL IN A WET YEAR, 1909

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	−0.06	−0.05	−0.08	−0.08	−0.02	−0.13	−0.12	−0.12	−0.09	−0.10	+0.44	−0.05
2	− .06	− .06	− .07	− .07	− .02	+ .32	+ .74	− .10	+ .14	− .09	− .09	+ .07
3	− .06	− .07	− .08	− .07	− .11	− .13	− .13	− .07	+ .21	− .08	− .09	− .06
4	− .06	− .08	− .08	− .08	− .12	+ .73	− .11	− .07	− .09	− .08	− .10	+ .14
5	− .04	+ .73	− .08	− .01	− .14	− .13	− .05	− .08	− .10	− .08	− .10	+ .44
6	− .06	− .09	− .08	+ .59	− .14	− .12	− .12	− .07	− .11	− .08	− .10	− .07
7	+ .07	− .09	− .08	− .09	− .13	+ .75	− .14	− .06	− .12	− .08	+ .45	+ .48
8	− .06	+ .51	+ .36	− .10	+ .10	+ .71	− .12	− .06	− .07	− .08	+ .03	− .08
9	− .06	+ .33	+ .09	− .07	+ .18	− .03	− .12	− .04	− .06	− .08	− .11	− .08
10	− .07	− .09	− .07	− .10	− .12	− .12	− .12	− .06	− .12	+ .17	− .09	− .01
11	− .07	− .09	− .07	− .10	− .11	− .12	− .11	+ .53	− .12	0	+ .03	+ .07
12	− .07	− .09	− .07	+1.05	− .08	+ .04	− .10	+ .16	− .12	− .08	− .04	+ .77
13	− .05	− .09	− .07	+0.04	− .09	− .11	− .09	+ .02	− .12	− .08	− .07	+ .52
14	− .08	+ .58	− .08	− .11	+ .36	− .11	− .10	+3.41	+ .99	− .09	− .03	− .06
15	+ .08	+ .32	− .05	− .01	− .08	− .11	− .10	+0.32	− .10	− .09	− .08	− .08
16	− .09	+ .06	− .06	+ .29	− .07	− .12	− .10	− .09	− .10	− .09	+ .88	− .03
17	− .09	− .07	− .07	− .09	− .07	− .11	− .09	− .09	− .10	− .08	− .08	− .07
18	− .08	+ .03	+ .29	+1.16	− .07	− .13	+ .03	− .10	− .09	− .08	− .08	− .07
19	− .08	+ .02	− .07	−0.10	− .07	− .13	− .09	− .12	− .09	− .08	− .07	− .07
20	− .08	− .07	− .08	− .10	− .09	− .13	− .09	− .12	− .09	+ .44	− .07	− .04
21	− .04	− .07	− .09	+ .57	− .09	− .11	− .10	− .12	+ .96	− .08	+ .08	− .03
22	+ .16	+ .03	− .09	− .10	− .10	+ .67	− .11	− .12	+ .73	+ .09	+1.07	− .07
23	− .07	+ .44	− .10	− .10	− .10	− .02	− .13	− .13	− .09	+ .10	−0.08	− .06
24	− .05	− .07	+ .24	− .08	− .11	+ .10	− .13	− .13	− .09	− .07	− .06	+ .18
25	− .05	− .07	− .09	− .09	+ .56	+ .50	− .12	+ .01	− .09	− .07	− .07	+ .44
26	− .05	− .07	+ .19	+ .09	+ .13	− .11	− .10	− .12	− .09	− .08	− .06	+ .09
27	− .04	− .07	− .10	− .01	− .11	− .05	− .12	+1.11	− .10	− .08	− .06	− .05
28	+ .67	− .08	− .10	+ .07	− .13	− .12	− .07	−0.10	− .10	− .09	+ .03	+ .07
29	+ .60	......	− .10	+2.65	− .13	− .13	+ .41	− .09	− .10	− .09	− .07	− .06
30	− .05	......	− .09	−0.10	− .13	− .12	− .14	− .09	− .10	− .08	− .07	− .06
31	− .05	......	− .09	......	− .09	......	− .13	− .09	......	− .09	......	− .06
Monthly	−0.04	+1.68	−0.92	+4.85	−1.19	+1.43	−1.87	+3.32	+0.58	−1.35	+1.34	+2.11
Accumulated	−0.04	+1.64	+0.72	+5.57	+4.38	+5.81	+3.94	+7.26	+7.84	+6.49	+7.83	+9.94

month to month. The years 1909, 1910, and 1911, wet, dry, and nearly normal, respectively, in their total amounts, have been selected, as they are quite typical of their classes. The accumulated departures at the bottom of the table, just beneath the monthly

departures, carry the excess or deficiency forward in each instance, and the last in each table indicates the departure for the year illustrated.

In the wet year 1909, February, April, June, August, September, November, and December have each an excess of precipitation, while the remaining months have a deficiency. The accumulated departures, however, show that, beginning with February, there was an excess throughout the remainder of the year, the amount at the end of December being above the normal by 9.94 inches.

TABLE XCIV

DAILY DEPARTURE IN INCHES OF PRECIPITATION FROM NORMAL IN A DRY YEAR, 1910

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	−0.06	−0.05	−0.08	−0.08	+0.24	−0.13	−0.12	0	−0.09	−0.10	−0.01	−0.06
2	− .05	+ .13	− .08	− .08	−1.03	+ .27	− .13	−0.10	− .08	− .09	− .08	− .06
3	− .06	− .06	− .08	− .08	−0.11	− .13	− .13	− .08	+ .47	+ .88	− .08	+ .02
4	+ .64	− .08	− .08	+ .35	− .12	+ .28	− .14	− .08	+ .95	+ .06	− .08	− .06
5	− .06	− .08	− .08	+ .13	− .14	− .13	− .14	− .08	+ .31	+ .08	− .10	− .05
6	− .06	− .09	− .08	− .08	− .14	− .07	− .13	− .07	+ .06	+ .15	− .10	− .07
7	− .06	− .09	− .08	− .09	− .34	− .12	− .14	− .06	− .12	− .08	− .10	− .06
8	0	− .09	− .07	− .10	− .04	− .12	− .12	− .06	0	− .08	− .11	− .08
9	− .06	− .09	− .07	− .10	− .13	− .12	− .09	− .06	− .12	− .08	− .10	− .03
10	− .07	− .09	− .07	− .10	− .04	− .12	− .12	− .06	− .12	− .08	− .04	+ .16
11	− .07	− .09	− .07	+ .32	− .06	− .12	+ .09	− .06	− .12	− .08	− .09	− .07
12	+ .48	− .09	− .07	− .11	− .11	− .11	+ .24	− .07	+1.16	− .08	− .09	− .07
13	+ .52	− .09	− .07	− .11	− .11	− .11	− .09	− .07	−0.12	− .08	− .09	− .07
14	+ .08	− .08	− .08	− .11	− .10	− .11	− .06	− .08	− .11	− .09	− .08	− .08
15	− .08	− .08	− .08	− .11	− .08	− .11	+ .24	+ .47	− .10	− .09	− .08	− .08
16	− .09	− .08	− .08	+ .09	− .07	− .12	− .10	+ .06	− .10	− .09	− .08	− .07
17	+ .61	− .07	− .07	− .06	+ .18	− .12	+ .30	− .09	− .10	− .08	− .08	− .07
18	− .05	− .07	− .07	− .04	− .07	− .09	− .10	− .05	− .09	− .08	− .08	+ .01
19	− .08	− .07	+ .09	− .10	− .07	− .13	− .09	− .12	− .09	− .08	− .07	− .07
20	− .03	+ .01	0	− .10	− .07	− .13	− .09	+ .28	− .09	− .05	− .03	− .07
21	− .01	− .04	− .09	− .10	+ .08	− .13	− .10	− .12	− .09	+ .18	− .08	− .07
22	− .07	− .01	− .09	+ .59	+ .72	− .13	+ .32	− .12	− .09	− .08	− .08	− .04
23	− .07	− .07	− .10	+ .11	+ .53	− .12	− .13	+1.68	+ .06	− .08	− .06	− .05
24	− .05	− .07	− .09	+ .11	− .11	− .12	− .13	−0.13	+ .02	− .07	+ .05	− .06
25	− .05	− .07	− .09	+ .43	− .11	− .12	− .12	− .13	− .09	− .07	− .07	− .03
26	+ .01	+ .45	− .10	+ .12	− .12	− .11	− .12	− .12	− .03	− .08	+ .10	− .06
27	− .03	− .08	− .10	− .07	− .12	− .11	− .12	− .11	− .10	− .07	+ .62	− .06
28	− .04	− .08	− .10	− .10	+ .15	− .12	− .13	− .10	− .10	− .09	− .07	+ .65
29	− .05	......	− .10	− .10	+ .21	− .13	− .13	− .09	− .10	− .09	− .07	+ .02
30	+ .03	......	− .04	+ .53	− .13	− .12	− .14	− .09	− .10	− .08	+ .04	− .06
31	− .05	......	− .09	......	− .13	......	− .13	− .09	......	− .09	......	− .06
Monthly	+1.07	−1.27	−2.26	+0.96	+1.30	−2.75	−1.85	+0.20	+0.88	−0.76	−1.19	−0.75
Accumulated	+1.07	−0.20	−2.46	−1.50	−0.20	−2.95	−4.80	−4.60	−3.72	−4.48	−5.67	−6.42

In the dry year 1910, there was an excess of precipitation in January, April, May, August, and September, and in the remaining seven months a deficiency. Beginning with February the accumulated monthly departures indicate a deficiency which at the end of the year amounted to 6.42 inches.

In 1911, the year which was nearly normal in total precipitation, there was a considerable deficiency throughout the first seven

months, although there was a slight excess for the months of February and April, while May was exactly normal. Beginning

TABLE XCV

Daily Departure in Inches of Precipitation from Normal in a Nearly Normal Year, 1911

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	0	−0.05	−0.08	−0.08	+0.18	−0.13	−0.12	+0.14	−0.09	+1.12	−0.09	−0.03
2	−0.06	− .06	− .08	+ .16	− .09	− .05	− .13	− .10	− .08	−0.09	− .09	+ .12
3	− .06	− .07	− .08	− .07	− .11	− .12	− .13	− .08	− .08	+ .31	− .09	+ .09
4	− .03	− .08	− .08	+ .69	− .12	− .13	− .14	− .08	− .10	− .08	− .10	− .06
5	+ .07	+ .63	− .08	− .08	− .14	− .13	− .14	− .07	+ .07	− .07	0	− .06
6	− .03	+ .09	− .08	− .04	− .14	− .09	− .15	− .07	+ .21	+ .17	+ .21	− .07
7	− .05	− .09	− .08	− .09	− .13	− .12	− .14	− .06	− .04	− .08	− .10	− .06
8	0	− .09	− .07	− .10	+ .03	− .12	− .01	− .06	− .12	− .08	− .11	+ .01
9	− .06	− .09	− .07	− .10	− .13	− .12	− .12	− .06	− .12	− .08	+ .01	− .03
10	− .07	− .09	− .07	− .10	− .12	− .12	− .09	+ .14	+ .07	− .08	− .08	+ .36
11	+ .18	− .09	− .03	− .05	− .11	+ .17	− .07	+ .50	− .09	− .08	+1.39	− .07
12	− .07	− .09	+ .19	− .07	− .11	− .11	− .10	+ .75	− .09	− .08	−0.06	− .07
13	+ .48	+ .19	− .07	+ .51	− .11	− .11	− .09	+1.36	− .04	− .08	− .09	− .07
14	− .08	− .08	− .08	− .11	− .10	− .10	− .10	+0.08	+1.04	+ .01	− .02	− .08
15	− .08	− .08	− .08	− .11	− .08	− .11	+ .31	− .08	−0.09	− .09	− .08	− .08
16	− .09	+ .03	− .08	− .10	− .07	+ .37	+ .06	− .05	− .10	+ .39	+ .20	+ .43
17	− .09	+ .48	− .07	− .09	− .07	+ .47	− .09	− .06	− .10	− .08	+ .42	− .07
18	− .08	− .06	− .07	− .03	− .07	− .13	− .10	− .10	+ .90	− .08	− .08	− .07
19	− .08	+ .03	− .07	+ .23	− .01	− .13	+ .37	− .12	− .09	− .08	− .01	− .07
20	− .08	− .03	− .08	− .05	+ .68	− .13	− .09	− .12	− .09	+ .13	− .04	+ .08
21	− .08	− .07	− .09	+ .13	+ .75	− .13	− .10	− .12	+ .33	+ .63	− .08	− .02
22	− .07	− .07	+ .09	− .10	+ .27	− .13	− .11	− .08	− .09	+ .06	− .06	− .04
23	− .07	− .07	− .10	− .10	− .08	− .12	+ .78	− .13	− .09	− .08	− .08	− .06
24	− .05	− .07	− .09	− .09	− .11	+ .68	− .06	− .04	+ .06	− .07	− .06	− .06
25	− .03	+ .22	− .09	− .09	− .11	− .03	− .08	− .13	0	− .07	− .07	− .06
26	− .05	− .07	+ .39	− .10	− .12	+ .03	− .12	− .12	− .09	− .06	− .06	+ .17
27	− .04	− .08	+ .11	− .10	− .10	− .11	− .12	− .11	− .03	− .08	− .06	− .05
28	− .04	− .08	− .06	+ .13	+ .64	− .12	− .12	− .02	+ .04	− .09	+ .19	− .06
29	− .05	......	+ .07	+ .21	− .10	− .13	− .13	− .09	− .10	− .09	− .07	− .05
30	− .05	......	− .03	− .06	− .13	− .12	− .14	− .09	+ .01	+ .14	− .07	+ .51
31	− .02	......	− .09	......	− .09	......	+ .28	− .09	......	− .05	......	− .01
Monthly	−0.83	+0.11	−1.10	+0.15	0	−1.12	−0.99	+0.84	+1.01	+1.24	+0.77	+0.47
Accumulated	−0.83	−0.72	−1.82	−1.67	−1.67	−2.79	−3.78	−2.94	−1.93	−0.69	+0.08	+0.55

with August the precipitation was uniformly above the normal, so that by the end of the year the deficiency was made up, and the excess of 0.55 inch had been accumulated.

HOURLY PRECIPITATION

1. *Mean hourly rainfall.*—The mean hourly rainfall, by months, from April to October, inclusive, is shown in Table XCVI. The 10-year period 1902–11 has been taken as a basis of calculation for the mean values given, as prior to 1902 the local hourly records were kept on Eastern Time, which differs an hour from the standard of time in use in Chicago. The cold months could not be included because automatic records of precipitation are not possible in freezing weather. These values from hour to hour are apparently as irregular as the occurrence of precipitation from day to day (p. 198), and

TABLE XCVI

MEAN HOURLY RAINFALL IN INCHES BY MONTHS, AND TOTAL HOURLY RAINFALL, APRIL TO OCTOBER, 1902–11

	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Mdt.
April	0.11	0.11	0.10	0.12	0.12	0.13	0.10	0.09	0.14	0.12	0.11	0.06	0.06	0.06	0.11	0.22	0.15	0.17	0.21	0.12	0.23	0.31	0.19	0.08
May	.15	.14	.16	.10	.12	.10	.19	.10	.12	.14	.16	.25	.06	.06	.12	.16	.16	.30	.14	.20	.24	.09	.12	.10
June	.15	.14	.08	.13	.24	.16	.08	.06	.10	.07	.07	.06	.04	.06	.12	.19	.08	.08	.18	.10	.12	.16	.10	.13
July	.07	.05	.04	.10	.16	.14	.14	.19	.06	.03	.01	.29	.31	.23	.16	.13	.11	.20	.10	.16	.36	.11	.14	.07
August	.23	.20	.28	.17	.08	.20	.25	.22	.06	.10	.10	.10	.06	.19	.14	.13	.11	.18	.27	.05	.02	.22	.17	.16
September	.12	.34	.19	.22	.11	.23	.17	.10	.09	.12	.07	.06	.06	.09	.12	.10	.14	.24	.15	.17	.31	.26	.15	.21
October	.10	.04	.04	.08	.06	.06	.05	.05	.05	.05	.03	.04	.02	.02	.04	.13	.06	.08	.06	.12	.09	.09	.04	.04
Sums	0.93	1.02	0.89	0.92	0.89	1.02	0.98	0.81	0.62	0.63	0.55	0.86	0.61	0.71	0.81	1.06	0.81	1.25	1.11	0.92	1.37	1.24	0.91	0.79
Means	0.13	0.15	0.13	0.13	0.13	0.15	0.14	0.12	0.09	0.09	0.08	0.12	0.09	0.10	0.12	0.15	0.12	0.18	0.16	0.13	0.20	0.18	0.13	0.11

Table XCVI contains the average amount of rainfall which has occurred during each hour of the day of each month from April to October, inclusive, 1902–11. These months only are given, as the self-recording rain gage from which the records are secured is not exposed during the colder months. See Fig. 41.

the table, together with Fig. 41, will at least be interesting in indicating these irregularities. The heaviest rainfall is shown to occur at about 1 and 9 P.M. in July, at about 2 A.M. and 9 P.M. in September, and at about 6 P.M. in May. The hours on either side of these periods are also marked by precipitation somewhat above the average, but it is probable that some of the heaviest records are affected by one or two heavy rains. However, while there appears to be no decided reason why greater rainfall occurs in some of the hours than in others, there is yet, in general, a relation to be seen between the times of greatest hourly rainfall and the times of occurrence of thunderstorms (p. 209).

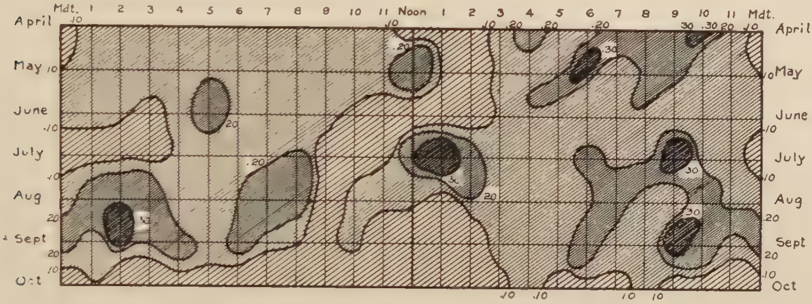


FIG. 41.—Average hourly precipitation.

Fig. 41 shows the average hourly precipitation in inches for each month from April to October, inclusive, 1902 to 1911. The lightest shading shows the time of the year and day when the precipitation averages the least, and the average depths increase with the shading (see Table XCVI).

2. *Hourly frequency of precipitation.*—There is a much greater regularity in the mean hourly frequency of precipitation than was found in the mean hourly amounts of rainfall in the preceding paragraph. Table XCVII shows the number of times that precipitation of any amount or character has occurred in the respective hours for the period 1902–11, inclusive. The data in this table, however, are not strictly comparable, as the number of days differs from month to month, and the number of times in which precipitation is possible is less, therefore, in the shorter months of the year. Because of this fact, the values given have been reduced to the percentage basis, as shown in Table XCVIII, and the hourly frequency drawn in Fig. 42 from the latter values. This method affords proper means of comparison with regard to the monthly and annual percentages as well as to the hourly frequencies. Taking the day as a whole, the

TABLE XCVII

HOURLY FREQUENCY OF PRECIPITATION (NUMBER OF TIMES), 1902–11

Mdt.	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Mdt.	Total	No. Times Precipitation was Possible in Each Hour
January	53	63	61	61	61	65	72	80	87	84	73	73	76	79	73	66	62	67	65	67	60	72	67	62	1,649	310
February	54	55	58	52	43	44	45	54	69	71	71	68	71	74	69	69	64	64	63	69	64	65	66	60	1,482	282
March	47	58	60	50	46	49	57	59	51	52	59	56	64	62	62	62	58	58	53	50	54	62	53	55	1,337	310
April	47	46	46	44	45	48	52	54	51	53	50	60	54	55	58	61	55	44	56	50	51	52	56	46	1,234	300
May	39	40	40	43	39	38	42	39	31	32	31	42	42	43	50	51	46	59	45	42	45	50	42	40	1,011	310
June	34	36	29	26	27	29	31	29	22	23	29	24	27	31	32	34	30	30	29	32	35	31	31	33	714	300
July	22	26	24	25	23	21	30	27	22	21	11	32	36	35	33	27	19	24	26	24	34	33	25	25	625	310
August	25	25	23	25	22	25	29	25	25	25	27	18	24	21	20	17	26	25	23	27	26	17	19	24	563	310
September	23	33	31	33	31	33	43	34	27	25	21	26	25	26	32	32	33	30	31	31	33	32	29	28	722	300
October	27	27	26	30	27	29	38	33	31	28	26	33	32	34	32	32	33	32	33	26	28	27	30	26	720	310
November	34	32	37	29	30	30	40	43	48	46	44	45	40	42	40	38	35	35	40	34	40	43	40	37	922	300
December	59	63	63	56	52	56	60	66	74	77	74	72	75	74	71	71	71	73	65	63	65	60	60	60	1,580	310
Total	464	504	498	474	446	467	539	543	538	537	516	549	566	576	572	560	532	541	529	515	535	544	518	496	12,559	Total for Period 87,648

Table XCVII shows the number of times precipitation of any amount and character has occurred within the respective hours for a period of 10 years, 1902–11. See Fig. 42.

greatest frequency is in the colder months, because the monthly frequency is also then greatest (p. 168). But in comparing similar hours of the day throughout the different months of the year, it is apparent that precipitation occurs most frequently in the middle of the day in winter, while in the warmer season not much difference is to be noted from one hour to another. In the former period the percentage of frequency is from 20 to 28, which means that in January precipitation occurs between 8 A.M. and 4 P.M. on one day in about every four. The highest percentage, 28, is at 9 A.M. in this month. The least hourly frequency is 4 per cent, at 11 A.M. in July, and the 3-hour period ending at this time has the least frequency of the year, rain

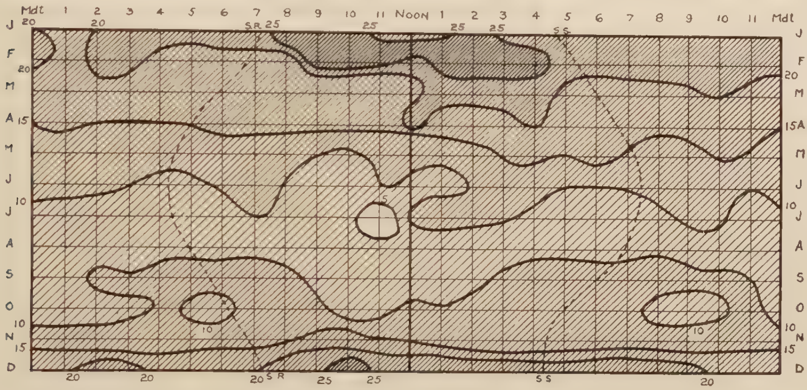


FIG. 42.—Hourly frequency of precipitation.

Fig. 42 gives the hourly frequency of precipitation of any amount and character expressed in terms of percentage of possible frequency. The space without shading indicates the time of the year and day when precipitation occurs least, and the frequency increases with the depth of shading. The dotted lines, marked *S.R.* and *S.S.*, show the time of sunrise and sunset, respectively (see Tables XCVII and XCVIII).

occurring then on only one day in about sixteen. The frequency by hours gradually diminishes from January to July and August, and increases thereafter during the remainder of the year. The average hourly frequency for June, September, and October is 10 per cent, representing an occurrence of precipitation on one day in ten. The least is in July and August, when the percentage is 8, and the greatest is in January and February, 22 per cent. The annual hourly frequency is 14.3 per cent, giving an average occurrence for any hour of one in seven. In these data all precipitation has been included, whether more or less than 0.01 inch in amount. A fall of 0.01 inch may extend over five or six hours, or even many more, and yet in each hour the fall would be inappreciable.

TABLE XCVIII

HOURLY FREQUENCY OF PRECIPITATION (PERCENTAGE OF POSSIBLE), 1902–11

	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Mdt.	Mean
January	17	20	20	20	20	21	23	26	28	27	24	24	24	26	24	21	20	22	21	22	19	23	22	20	22
February	19	20	21	18	15	16	16	19	25	25	25	24	25	26	25	25	23	23	22	25	23	23	23	21	22
March	15	19	19	16	15	16	18	19	16	17	19	18	21	20	20	20	19	19	17	16	17	20	17	18	18
April	16	15	15	15	15	16	17	18	17	18	17	20	18	18	19	20	18	15	19	17	17	17	19	15	17
May	13	13	13	14	13	12	14	13	10	10	10	14	14	14	16	16	15	19	14	14	14	16	14	13	14
June	11	12	10	9	9	10	10	10	7	8	10	8	9	10	11	11	10	10	10	11	12	10	10	11	10
July	7	8	8	8	7	7	10	9	7	7	4	10	12	11	11	9	6	8	8	8	11	11	8	8	8
August	8	8	7	8	7	8	9	8	8	8	9	6	8	7	6	6	8	8	7	9	8	6	6	8	8
September	8	11	10	11	10	11	14	11	9	8	7	9	8	9	11	11	11	10	10	10	11	11	10	9	10
October	9	9	8	10	9	9	12	11	10	9	8	11	10	11	10	10	11	10	11	8	9	9	10	8	10
November	11	11	12	10	10	10	13	14	16	15	15	15	13	14	13	13	12	12	13	11	13	14	13	12	13
December	19	20	20	18	17	18	19	21	24	25	24	23	24	24	23	23	23	24	21	20	21	19	19	19	21
																							Annual.....		14.3

Table XCVIII shows the hourly frequency of precipitation of any amount and character in terms of the percentage of possible occurrence. This table is based upon Table XCVII and the values are graphically represented in Fig. 42.

SUMMARY OF PRECIPITATION DATA

The main features of the precipitation data treated in the foregoing pages and tables have been collected in a single page. Table XCIX will therefore furnish a summary of the more important values for reference.

THUNDERSTORMS

Thunderstorms usually occur in the southeast quadrant of a general storm area, and are often attended by severe squalls and hail. Damage by lightning seldom or never occurs in the business district of Chicago, because the discharges are carried away quietly into the ground by the steel framework of the numerous skyscrapers. Damage does, however, occur sometimes in the residence sections, where the means of protection mentioned is wanting. Even there thunderstorms are rarely of the severest type, such as those which occur in the states of the Great Plains, and it is probable that the cool waters of the lake exercise a decided weakening influence upon the activity of these disturbances.

1. *Annual and monthly frequency.*—Table C gives the number of days with thunderstorms each month and year from 1880 to 1913. The annual occurrence is graphically shown in Fig. 43, and the average monthly frequency in Fig. 44. The average annual number of such days is 33, but the figures for the various years indicate a wide range, from 51 in 1904 to 18 in 1893, one of the longest and most pronounced summer drouths occurring in the latter year (p. 192). June is the month of greatest frequency, with an average occurrence of 6.3, but each month from May to August averages 5 or more. The frequency is, of course, least in the winter season, averaging less than 1 each month from November to February, with the lowest average 0.1 in December. While June is the month of greatest frequency, and several instances of the occurrence of 10 or more days will be noted in that period, the highest individual record is 14, in May, 1902 and 1912. Two thunderstorms occurred in January, 1909, 1907, and 1906, and two in February, 1906, but in no other winter months have more than one been recorded.

2. *Hourly frequency.*—Table CI and Fig. 45 show the average occurrence of thunderstorms by hours, based upon data from 1901 to 1910, inclusive. It is apparent that by far the larger proportion of these storms happen during the latter half, or heated portion, of the day. A count of those recorded in the table gives 303 of the

TABLE XCIX

SUMMARY OF PRECIPITATION DATA, 1871–1910

	Means				Monthly and Annual Amounts						Number of Days with Precipitation*			Average Duration of Precipitation, 1891–1910, Hours	Greatest in Twenty-four Hours	
	Means	As Percentage of Annual Mean	Mean Departure		Greatest			Least			Average	Greatest	Least		Depth	Year
			Inches	Per-centage	Depth	Year	Per-centage of Mean	Depth	Year	Per-centage of Mean						
January	2.10	6	0.10	5	4.53	1897	216	0.54	1879	26	11	19	5	7.5	1.80	1907
February	2.30	7	0.14	6	5.98	1881	260	0.06	1877	3	11	17	2	8.1	1.94	{1883, 1876}
March	2.51	7	0.04	2	5.37	1877	214	0.29	1910	12	12	19	3	6.8	3.26	1884
April	2.87	9	0.01	0	7.73	1909	269	0.14	1899	5	11	18	5	4.7	2.75	1909
May	3.54	11	0.17	5	7.32	1883	207	0.84	1897	24	12	17	6	3.1	2.82	1873
June	3.49	10	0.17	5	10.58	1892	303	0.55	1904	16	11	19	4	2.1	3.44	1885
July	3.53	11	0.11	3	9.56	1889	271	0.58	1874	16	10	17	2	2.2	4.14	1878
August	3.10	9	0.22	7	11.28	1885	364	0.18	1893	6	9	15	2	2.5	6.19	1885
September	3.09	9	0.07	2	8.28	1894	268	0.32	1891	10	9	14	2	3.3	3.44	1875
October	2.38	7	0.17	7	7.36	1883	310	0.18	1897	8	9	19	1	3.9	2.55	1877
November	2.52	8	0.02	1	6.08	1877	241	0.31	1904	12	10	17	4	6.0	3.39	1883
December	2.09	6	0.02	1	6.76	1895	323	0.16	1896	8	11	20	5	8.1	2.66	1895
Year	33.52	100	1.24	4	45.86	1883	137	24.52	1901	73	125	166 in 1878	106 in 1895, 1910	4.9	6.19	1885

* Omitting days with only a trace of rainfall or snowfall.

Table XCIX contains a summary of the more important precipitation data. The first column contains the mean precipitation, the second column the same values expressed in percentages of the annual mean, the third column contains the average departure from the mean, either above or below, and the fourth column contains the same values expressed in percentages. The remaining columns are self-explanatory.

total number of 438, or 68 per cent, as having occurred in that period. It is evident from the graph that the afternoon is divided into two shorter periods of comparatively great frequency, from 1 to 5 P.M., and from 8 to 11 P.M., while the individual hours at which thunderstorms recur oftenest are 1 P.M. and 5 P.M. in July, when the average

TABLE C

NUMBER OF DAYS WITH THUNDERSTORMS EACH MONTH AND YEAR, 1880–1913

(See Figs. 43 and 44)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1880........	......	1	1	7	7	2	7	6	3	3	......	......	37
1881........	......	1	......	1	3	7	7	1	5	......	1	1	27
1882........	......	......	2	7	1	8	3	9	1	3	1	......	35
1883........	......	......	......	4	4	1	6	3	......	1	2	......	21
1884........	......	......	......	2	2	4	6	2	1	2	1	......	20
1885........	......	......	......	......	5	3	9	7	1	......	1	1	27
1886........	......	......	1	3	4	7	4	5	5	......	......	......	29
1887........	1	1	......	2	5	3	5	2	3	1	......	......	23
1888........	......	......	......	2	9	5	6	6	2	1	1	......	32
1889........	......	......	1	3	6	5	7	3	1	1	......	......	27
1890........	1	......	1	4	5	12	4	3	2	1	......	......	33
1891........	......	1	1	2	2	6	4	4	2	1	1	......	24
1892........	......	......	......	4	5	12	2	3	3	1	......	1	31
1893........	......	......	......	5	2	4	5	......	1	1	......	......	18
1894........	......	......	2	4	8	7	2	4	8	2	......	......	37
1895........	1	......	1	......	4	4	8	6	4	......	......	......	28
1896........	......	......	1	4	7	5	2	5	5	1	......	......	30
1897........	1	1	3	4	5	7	3	4	1	1	......	......	30
1898........	1	......	3	......	4	6	5	6	8	2	......	......	35
1899........	......	......	......	1	12	7	6	4	3	......	1	......	34
1900........	......	1	......	1	7	7	7	12	4	2	2	......	43
1901........	......	......	1	......	5	13	9	5	3	1	1	......	38
1902........	......	......	1	1	14	10	9	4	2	3	......	......	44
1903........	......	......	2	6	6	1	9	9	6	2	1	......	42
1904........	......	1	5	3	4	8	11	7	7	5	......	......	51
1905........	......	......	4	4	8	11	8	5	5	2	......	......	47
1906........	2	2	......	3	3	7	4	7	4	......	......	......	32
1907........	2	......	5	3	5	7	7	7	5	2	......	......	43
1908........	......	1	5	3	7	7	8	5	3	......	2	......	41
1909........	2	1	......	5	4	8	3	7	2	......	2	......	34
1910........	......	......	3	4	4	2	7	3	5	1	2	......	31
1911*........	......	......	......	4	6	6	7	7	10	3	1	......	44
1912*........	......	......	......	2	14	7	8	9	5	3	1	......	49
1913*........	......	......	4	1	4	3	5	7	2	1	1	......	28
Totals 1880–1912......	11	11	43	98	187	209	198	170	120	46	22	3	1,067
Average.....	0.3	0.3	1.4	3.0	5.4	6.3	5.9	5.0	3.4	1.3	0.6	0.1	33.0

* Not included in averages.

is 9 at each. Taking the year as a whole the time of greatest frequency is 9 to 11 P.M., and of the least, from 2 to 3 A.M. The ocurrence of comparatively many thunderstorms at about 4 A.M. in May will be noted. This feature is remarkable, and finds its explanation in the alternation of lake and land breezes, already described at some length (p. 142), the night land breeze being at its height at that hour (p. 306), and with the rapidly increasing warmth of spring bringing about conditions favorable for the formation of thunderstorms.

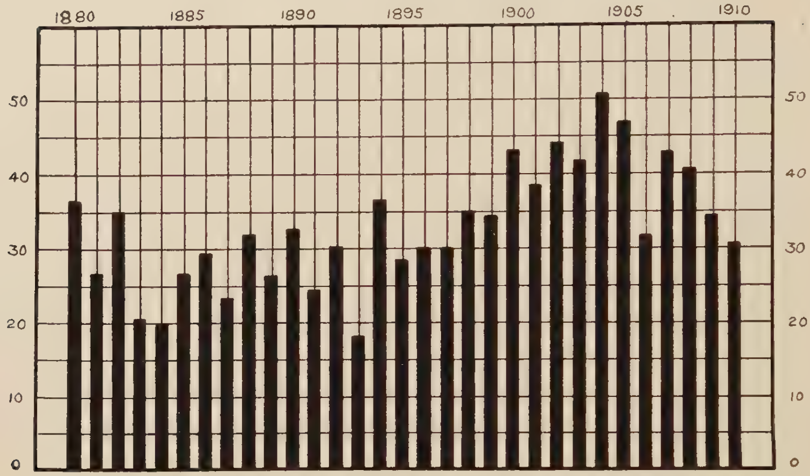


FIG. 43.—Annual frequency of days with thunderstorms from 1880 to 1910 (see Table C).

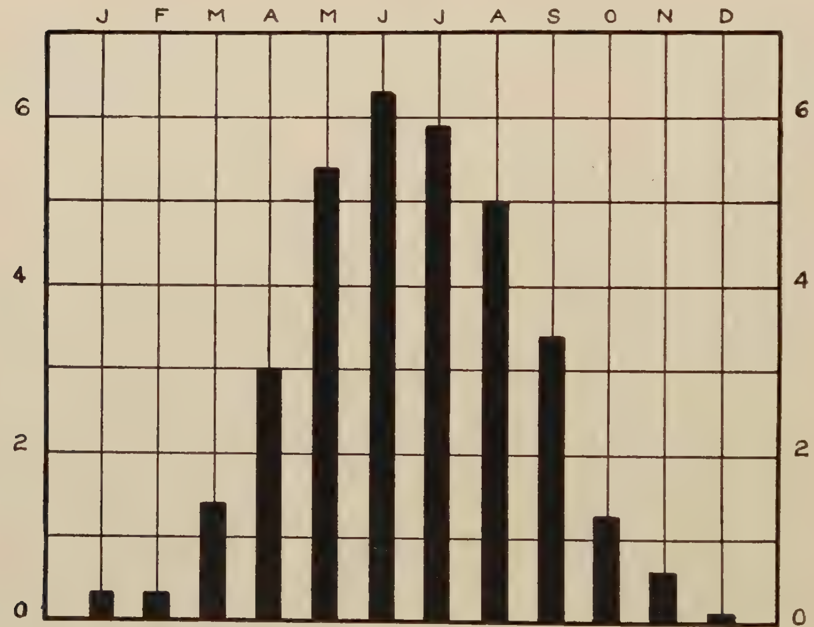


FIG. 44.—Average monthly frequency of days with thunderstorms, 1880 to 1910 (see Table C).

TABLE CI

FREQUENCY AND TIME DISTRIBUTION OF THUNDERSTORMS, 1901–10

	Mdt.	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Mdt	Total
January	.....	.....	.....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	1	2		7
February	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	.....	1	.....	.....	.....	.....		5
March	.....	1	.....	.....	2	.....	.....	.....	1	2	.....	.....	1	1	1	3	2	2	4	.....	3	2	.....	3		28
April	2	1	1	1	1	.....	1	1	1	1	.....	.....	.....	2	2	6	2	1	3	2	6	.....	2	.....		36
May	3	1	.....	6	3	.....	3	1	.....	2	3	4	5	5	4	4	3	6	3	5	5	3	6	.....		75
June	4	4	2	.....	3	1	2	1	4	1	.....	5	4	6	5	5	3	5	3	4	5	7	6	2		82
July	2	2	1	.....	3	1	1	1	.....	2	3	4	9	6	4	4	9	5	1	6	8	7	.....	1		80
August	.....	2	3	1	1	2	2	1	1	2	.....	1	3	5	3	5	3	2	6	2	6	2	3	2		58
September	3	2	.....	5	1	2	1	1	.....	.....	1	1	3	1	5	2	2	3	2	4	1	2	.....	1		43
October	1	1	.....	1	.....	.....	.....	1	.....	1	.....	1	.....	.....	.....	2	3	1	2	.....	.....	.....	1	.....		15
November	.....	.....	.....	.....	.....	1	.....	1	.....	.....	1	.....	1	1	1	.....	.....	.....	.....	.....	1	.....	2	.....		9
December	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		0
Total	16	15	7	14	14	7	11	8	8	11	8	16	26	28	26	32	27	26	24	24	35	23	21	11		438

Table CI shows the frequency and time distribution of thunderstorms based upon a record of 438 such storms from 1901 to 1910. The numbers in the various columns indicate the number of thunderstorms beginning within the respective hours, without regard to the length of time the storm continued. When more than one thunderstorm occurred on the same day, each storm is included in the list above; whereas, in Table C, only the number of days on which thunderstorms occurred is used. See Fig. 45.

As the thunderstorm is a relatively small, local disturbance within the area of a much larger, general storm, it occasionally happens that when the latter moves across the country with less than the average velocity a succession of thunderstorms will occur within a space of several days at one place. A period of this character prevailed at Chicago on June 22, 23, and 24, 1892, during the meeting of the Democratic convention which nominated Cleveland for President. There were two thunderstorms on the 22d, one in the afternoon and the other in the evening continuing into the early

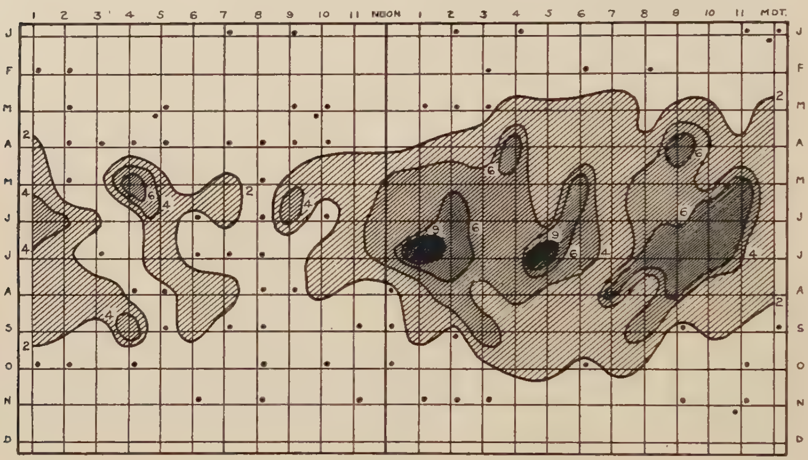


Fig. 45.

Fig. 45 shows the frequency and time distribution of thunderstorms, based upon records of 438 thunderstorms from 1901 to 1910. The dots in squares show number of thunderstorms for the hours not included in the shading. The heaviest shading shows the time of year and hour of greatest frequency (see Table CI).

morning of the 23d. A third quite heavy storm occurred on the afternoon of the 23d, and still another on the morning of the 24th. All these storms were marked by heavy thunder, vivid lightning, excessive rainfall, and on the 22d and 23d by severe squalls. On the second day 1.60 inches of rain fell in 1 hour, from 4:10 to 5:10 P.M., and 4.77 inches fell in the whole series of storms during the three days.

HAIL

Table CII gives the occurrence of hailstorms from 1887 to 1913, inclusive. When hail occurs it is usually in connection with thunderstorms. During the period of 27 years shown in the table, hail has

been noted 66 times. In 1897 the phenomenon occurred 7 times, while in three years, 1887, 1892, and 1913, it was absent altogether. It is most frequent in May, at the time of the most rapid change in temperature, and has occurred 16 times in that month during the period of record. The frequency of May is followed in order by June, with a total occurrence of 13, April with 11, and March with 10. It

TABLE CII

FREQUENCY OF OCCURRENCE OF HAIL, 1887–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1887	......	......	......	......	......	......	......	......	......	......	......	......	0
1888	......	......	......	1	......	1	......	1	......	1	......	......	4
1889	......	......	1	......	1	......	......	......	......	......	......	......	2
1890	......	......	......	......	1	......	......	......	......	......	......	......	1
1891	......	1	......	......	1	......	......	......	......	......	......	......	2
1892	......	......	......	......	......	......	......	......	......	......	......	......	0
1893	......	......	1	......	1	1	......	......	......	......	......	......	3
1894	......	......	......	3	3	......	......	......	......	......	......	......	6
1895	......	......	......	......	......	1	......	......	......	......	......	......	1
1896	......	......	......	......	......	1	......	1	......	......	......	......	2
1897	......	......	4	1	......	2	......	......	......	......	......	......	7
1898	......	......	......	......	1	1	1	......	......	......	......	......	3
1899	......	......	......	1	4	......	......	......	......	......	......	......	5
1900	......	......	......	......	......	......	......	1	......	......	......	......	1
1901	......	......	1	......	......	1	......	......	......	......	......	......	2
1902	......	......	......	......	......	......	1	......	......	......	......	......	1
1903	......	......	......	1	1	......	1	......	......	1	......	......	4
1904	......	......	1	......	......	......	1	......	......	......	......	......	2
1905	......	......	......	......	1	1	......	......	......	......	......	......	2
1906	......	......	......	1	......	1	......	......	......	......	......	......	2
1907	......	......	1	......	1	1	......	1	......	......	......	......	4
1908	......	......	1	1	1	......	......	......	......	......	......	......	3
1909	......	......	......	2	......	......	......	1	......	......	......	......	3
1910	......	......	......	......	......	2	......	......	......	......	......	......	2
1911	......	......	......	......	......	......	2	......	......	......	......	1	3
1912	......	......	......	......	......	......	......	1	......	......	......	......	1
1913	......	......	......	......	......	......	......	......	......	......	......	......	0
Total	0	1	10	11	16	13	6	6	0	2	0	1	66

occurs much less frequently after warm weather has set in, July and August having 6 and 5 hailstorms, respectively, and is noted but rarely during the other portions of the year. It has never been observed in September, November, or January, and has occurred but once in December, once in February, and twice in October. Hail is entirely distinct from sleet, which falls often in the winter season.

SNOW

Previous to 1884 the Weather Bureau maintained no distinct records of depth of snow, the falls being measured merely as melted, and included in the precipitation data together with rain. The combined record is still kept, but since the winter of 1884–85 the actual depth of snow has also been entered, regardless of the amount

of moisture contained therein. The average snow, when melted, will produce one-tenth of its depth in water, but there is a considerable variation from this proportion. Very wet snow may contain one-third or even one-half of its depth in water, while, on the other hand, light, dry, feathery snow may not give when melted more than one-twelfth to one-fifteenth of its depth in water.

A snow gage is maintained at the Weather Bureau office in the Federal Building, but the swirl of winds affects the catch of such a gage much more than is the case in the measurement of rainfall. In order to secure as high a degree of accuracy as is possible under city conditions, the actual depth of each snowfall is also measured in another manner. For this purpose, three separate measurements are made in Grant Park and the readings are averaged, the latter being used as the official record. At present a portion of the snow is also weighed and the moisture content found, but formerly the average content—one-tenth of the depth—was entered in all cases, as no suitable device for determining the content under all circumstances had been found. Any fall of snow of less than 0.1 inch in depth is regarded as inappreciable, and is recorded as "trace," as is an amount of less than 0.01 inch of rainfall.

SEASONAL AND MONTHLY SNOWFALL

The total and average snowfall by months and winters is shown in Table CIII, and the fall by winters, together with the average monthly amounts, is illustrated in Fig. 46. While there is a very great variation in the fall of snow from month to month, and from season to season, the average fall through the winter months, as seen from both graph and table, increases in a fairly gradual manner from the earliest snows of autumn to late winter, February having the greatest mean, 11.3 inches. The decrease in the amount of snowfall after the February maximum is reached is much more rapid than is the increase up to that time, chiefly because mean temperatures show then a greater rate of change and reach the melting point early in March. Although February has the greatest mean monthly snowfall, that of January is only slightly less, 10.2 inches; and, as a matter of fact, the period of heaviest snow extends from the latter portion of January to about the middle of February, there being a decided falling off during the last decade of the second month. The main snow-bearing wind at Chicago is that from the northeast, because it approaches the city after passing over the broad expanse

of the lake and is laden with moisture evaporated from its surface. The chill received from the colder land surface in winter, when temperatures are below freezing, rapidly condenses and crystallizes this moisture into snow. And so, with the fall of mean temperatures in the winter season to the minimum about February 1 (p. 26), the amount of snow gradually increases to its maximum, decreasing thereafter as the mean temperatures rise. In the spring and summer,

TABLE CIII

MONTHLY AND SEASONAL SNOWFALLS, IN INCHES AND TENTHS, 1884–1914

Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Total for Season
1884–85	T	0.5	8.8	20.2	19.0	3.6	1.9	0	54.0
1885–86	0	0.7	14.6	26.7	6.0	1.9	1.0	0	50.9
1886–87	0	2.6	9.8	17.7	4.2	6.2	T	0	40.5
1887–88	T	2.5	9.9	11.9	2.2	3.5	2.0	0.1	32.1
1888–89	T	0.5	3.2	6.0	7.9	5.1	T	T	22.7
1889–90	T	1.3	T	2.7	8.3	9.4	T	0	21.7
1890–91	T	T	7.1	3.5	1.1	7.7	2.2	T	21.6
1891–92	0	6.8	5.5	15.3	2.8	3.1	T	0	33.5
1892–93	0	0.8	2.1	15.2	11.8	1.0	0.6	0	31.5
1893–94	0	7.5	12.1	6.5	12.9	5.4	T	T	44.4
1894–95	0	2.5	10.1	15.4	14.0	5.2	0	T	47.2
1895–96	0	14.5	3.4	2.0	27.8	8.9	T	0	56.6
1896–97	T	4.2	1.3	13.1	14.6	10.9	0.9	0	45.0
1897–98	0	T	6.2	15.9	13.7	1.0	T	0	36.8
1898–99	T	1.8	2.7	2.6	3.5	7.4	T	0	18.0
1899–1900	0	T	3.5	0.3	22.6	6.8	3.6	0	36.8
1900–1901	0	1.1	3.6	9.2	21.1	5.9	T	0	40.9
1901–2	0	0.1	4.2	6.2	5.5	2.1	0.1	T	18.2
1902–3	0	0.5	5.3	5.0	19.5	0.7	3.2	0	34.2
1903–4	0	2.2	18.6	11.0	13.4	14.3	T	0	59.5
1904–5	T	T	6.8	8.5	14.1	4.5	0.2	0	34.1
1905–6	T	T	2.8	2.9	5.9	9.0	0	0	20.6
1906–7	T	2.8	0.3	10.9	10.0	2.1	1.9	1.3	29.3
1907–8	0	3.0	12.8	13.2	19.8	0.1	T	0	48.9
1908–9	0	0.9	2.7	8.6	10.1	3.8	0.3	T	26.4
1909–10	T	T	19.1	14.9	2.8	T	6.9	0	43.7
1910–11	T	1.2	9.3	2.2	9.8	4.9	2.4	T	29.8
1911–12*	T	1.2	7.8	7.1	9.9	13.5	0.1	0	39.6
1912–13*	0	0.4	T	6.1	4.7	7.9	T	0	19.1
1913–14*	1.9	T	2.7	14.8	7.2	1.2	....	....	....
Average	T	2.2	6.8	10.2	11.3	5.0	1.0	0.1	36.2
Greatest	T	14.5	19.1	26.7	27.8	14.3	6.9	1.3	59.5
Year	....	1895	1909	1886	1896	1904	1910	1907	1903–4
Least	0†	T†	T†	0.3	1.1	T	0†	0†	18.0
Year	....	....	....	1900	1891	1910	....	....	1898–99

* Not included in averages.

† In more than one year.

however, the lake wind usually brings fair skies and bright sunshine, because its temperature is largely increased and its relative humidity correspondingly lowered as it passes over the warmer land surface, so that condensation into clouds and rain is very infrequent at such times.

The greatest snowfall in any one winter was that of 1903–4, when 59.5 inches were recorded, an excess of 23.3 inches over the

average. This large amount was due chiefly to extraordinary falls of snow during December and March, nearly three times the average measurements being received in each of those months. The latter, 14.3 inches, was the greatest March snowfall on record, as with one

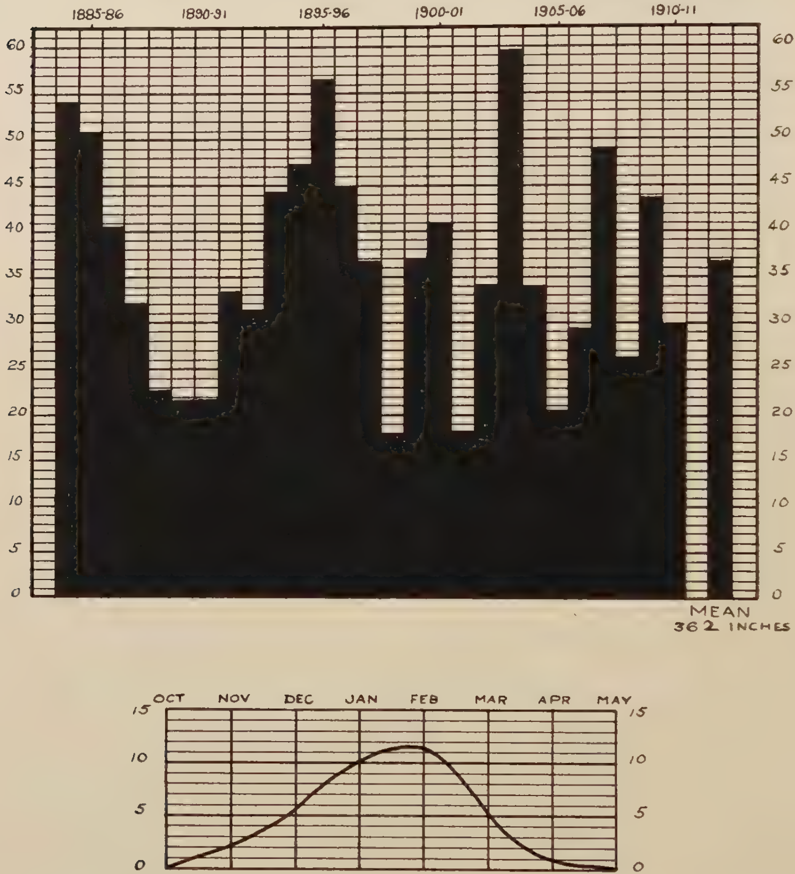


FIG. 46.—Total snowfall in inches by winters (upper graph); average monthly snowfall in inches (lower graph).

exception was that of December, 18.6 inches. Of these amounts, 11.3 inches fell in the single storm of December 12, and 8.7 inches in the storm of March 14–15. By months, the greatest individual records are: October, 1913, 1.9 inches; November, 1895, 14.5 inches; December, 1909, 19.1 inches; January, 1886, 26.7 inches;

February, 1896, 27.8 inches, this being the greatest amount of snowfall on record at Chicago for any month; March, 1904, 14.3 inches; April, 1910, 6.9 inches, of this amount 6.4 inches falling on the 22d to 26th; May, 1907, 1.3 inches in the single storm of the 3d. Snow rarely falls in October, nor does it occur often in May. No instances of measureable amounts have ever occcurred in the former month except the unprecedented fall of 1.9 inches in 1913, and there have been but two times that more than a "trace" has occurred in May. Once in June, on the 2d, in 1910, "trace" of snowfall was observed at the Weather Bureau office, in a thunderstorm condition which indicated an overlying blanket of very cold air, although the surface temperatures were in the 40's.

The smallest snowfall in any one winter was that of 1898–99, when but 18.0 inches were noted, but the record is closely followed by that of 1901–2, when only 18.2 inches fell. Remarkably small amounts were recorded in the following months: December, 1889, "trace"; January, 1900, 0.3 inch; February, 1891, 1.1 inches; March, 1910, "trace." There are several Novembers in which only a "trace" fell, and several Aprils in which no snow at all occurred.

There is no fixed relation between the mean temperature of a winter and the amount of its snowfall. The greatest seasonal snowfall, 59.5 inches in 1903–4, occurred in the coldest winter on record, 18°.3. The next greatest amount, which was but little less than that of 1903–4, was 56.6 inches in the winter of 1895–96, which season had a mean temperature of 27°.7, slightly above the average. Large amounts of snow fell also in the winter of 1884–85, which was colder than the average, and in the winter of 1885–86, which was warmer than the average. On the other hand, the smallest winter snowfall on record, 18.0 inches in 1898–99, occurred during a very cold season, while in 1905–6, with a mean temperature as much above the normal as the former was below, but 20.6 inches were recorded. During the winter of 1901–2, when only 18.2 inches of snow fell, the season was colder than usual; while in 1890–91, with a snowfall of but 21.6 inches, the mean temperature was considerably higher than the average. Absence of snow during a very cold winter causes much damage in the outer portions of the city, as was the case during the latter part of the winter of 1898–99, above mentioned, when many water and gas mains were frozen because they were unprotected from severe temperatures by snow covering. On the other hand, much snow in a very cold winter results in many accidents and great expense

in the business sections, because of the difficulty in removing the drifts and in keeping the pavements free from incrustations of ice. Such a condition existed during December and January in the winter of 1909–10, many accidents occurring on the slippery streets, while business was much delayed by innumerable piles of frozen snow in the thoroughfares, and by the ice coatings which rendered heavy loading impossible.

Extreme cold, however, should obviously be unfavorable for the occurrence of any considerable snowfall, as the moisture content of the atmosphere at such times is very small, yet low temperatures serve to keep the snow covering on the ground after the storm. Ordinarily, considering the storms in which our snows commonly occur, the heaviest falls are accompanied by temperatures ranging between 20° and 28°. At Chicago, when the temperature falls as low as 10°, the termination of the storm is soon at hand.

TABLE CIV

Annual Depth of Snowfall, in Inches, 1885–1913

(See Fig. 47)

Year	Depth in Inches	Year	Depth in Inches	Year	Depth in Inches	Year	Depth in Inches
1885	60.0	1893	48.2	1901	40.5	1909	41.9
1886	48.0	1894	37.4	1902	19.7	1910	35.1
1887	40.5	1895	52.5	1903	49.2	1911	28.3
1888	23.4	1896	44.2	1904	45.5	1912*	31.0
1889	20.3	1897	45.7	1905	30.1	1913*	23.3
1890	27.5	1898	35.1	1906	20.9		
1891	26.8	1899	17.0	1907	42.0	Mean	36.2
1892	24.1	1900	38.0	1908	36.7		

* Not included in mean.

The amount of snowfall for each calendar year of the period of record is shown in Table CIV, and graphically in Fig. 47, for purposes of reference in comparisons including annual precipitation, but the principal interest in the matter of snowfall naturally centers in winters, so that no discussion of the annual values is deemed necessary.

While the variation of snowfall from season to season, and from month to month, is great, a study of the tables and graphs presented leads to the conclusion that there has been no permanent change from greater to lesser amounts, as many people believe. Considering that the greatest Chicago snowfall of record occurred as recently as the winter of 1903–4, and that the amounts in the seasons of 1907–8 and 1909–10 were far above the average, it is obvious that

the snows of the present are just as heavy as were those of a generation ago. Many Chicagoans were born and reared in the northern and central portions of New England and New York state, where the snowfall is ordinarily much greater than it is in the Middle West, and such persons are likely to contrast the snowstorms of their childhood days with those of this region, and hastily conclude that the latter region has undergone a remarkable change in climate. Then, too, the snows of the present remain on the ground as long as did those of former years, because the character of our winter temperatures has suffered no permanent change. In the winter of 1909–10 snow lay on the ground continuously from December 5 to March 10, and sleighing was possible in the outlying sections of the city during three months of that period.

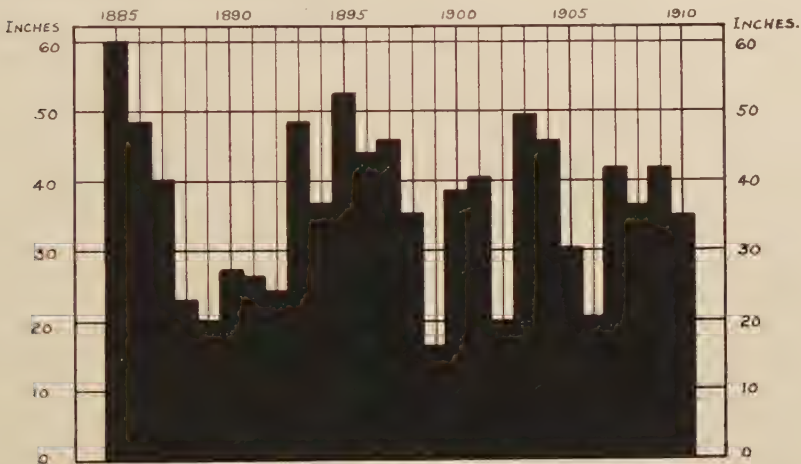


FIG. 47.—Annual depth of snowfall, in inches, 1885–1910 (see Table CIV).

In order to afford a comparison of the snowfall of the Chicago region with others of the country lying east of the Rocky Mountains, Fig. 48 has been prepared. There is an average annual snowfall over northern New England and northeastern New York amounting to 110 inches, while the fall exceeds 60 inches over the middle portions of those sections. The only portion of the country in the section shown in the figure, the annual snowfall of which exceeds that of New England, lies on the southern shore of Lake Superior, where northerly winds sweeping the lake bring an average of 130 inches. Until recent years no accurate measurements of snowfall have been

made in the western mountains, and late data are not yet available for publication, but the observations thus far obtained indicate that in certain localities extremely heavy falls occur, far surpassing those of the Lake Superior shore.

HEAVY SNOWFALLS

1. *Greatest snowfall in twenty-four consecutive hours, monthly.*—The greatest snowfall occurring in any twenty-four consecutive hours for each month since 1891, when this particular record was begun, is shown in Table CV. From this table it is apparent that the heaviest

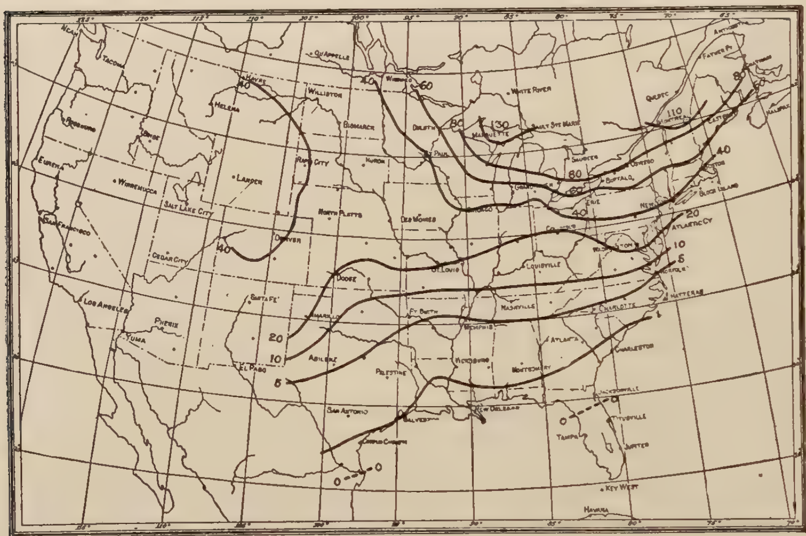


Fig. 48.—Average annual snowfall in the United States: depth in inches.

snowstorms occur most frequently in February, there having been 5 in that month with a fall of more than 10 inches within twenty-four hours, while no other month has more than 2 such storms. There is but a single instance of a 24-hour fall of more than 12 inches, that being on February 18–19, 1908, when 12.7 inches were recorded. Remarkably heavy snows, entirely out of the season when such depths might be expected, were those of November, 25–26, 1895, 11.5 inches, and of March 23–24, 1897, 10.0 inches, and both readings are by far the greatest recorded for their respective months. The heaviest 24-hour fall in December was 11.3 inches, in 1903, and

TABLE CV

Greatest Snowfalls in Twenty-four Consecutive Hours, in Inches and Tenths, 1891–1914

Season	October		November		December		January		February		March		April		May	
	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date
1891	......	......	......	......	......	......	2.5	2	0.3	8	3.2	2	1.5	5	T	4
1891–92	0	......	5.8	27	5.5	6	5.0	11	1.0	14	1.0	5	T	9	0	......
1892–93	0	......	0.8	25	1.0	18	5.7	24	8.7	17/18	0.5	19	0.4	21	0	......
1893–94	0	......	3.0	21	8.1	2/3	5.9	23/24	10.2	12/13	5.3	28	T	5*	T	18
1894–95	0	......	2.5	12	10.1	27	9.1	25/26	9.1	5/6	5.0	4	0	......	T	13
1895–96	T	20*	11.5	25/26	1.5	2	1.6	5/6	11.0	3	3.0	1*	T	2	0	......
1896–97	T	17	4.0	5	0.6	4	6.0	23/24	3.9	11/12	10.0	23/24	0.6	16	0	......
1897–98	0	......	T	2*	3.1	17	6.5	22/23	4.0	19	0.5	2	T	4*	0	......
1898–99	T	14*	1.2	25/26	1.5	22	1.0	17	2.8	22	3.0	30	T	1*	0	......
1899–1900	0	......	T	2*	2.4	14	0.3	13	11.3	27/28	2.5	29	2.9	11/12	0	......
1900–1901	0	......	1.0	14/15	2.8	31	3.1	26	11.4	3/4	3.5	30/31	T	2*	0	......
1901–2	0	......	0.1	18	2.6	13/14	3.0	20/21	1.2	6	1.5	30	0.1	8	T	10
1902–3	0	......	0.5	27	2.0	24	2.0	11	7.0	3/4	0.3	27	2.6	3	0	......
1903–4	0	......	1.4	28	11.3	12	3.4	12	4.8	18	8.4	14	T	2*	0	......
1904–5	T	22	T	13*	2.8	11/12	2.1	25	4.6	6	4.4	14	0.2	7	0	......
1905–6	T	11*	T	7*	1.5	1/2	0.7	22	1.8	14	3.4	19	0	......	0	......
1906–7	T	9*	1.4	12	0.2	21	2.1	16	7.0	5	1.6	10	1.2	13	1.3	3/4
1907–8	0	......	3.0	30	8.1	14	7.4	12	12.7	18/19	0.1	18	T	2*	0	......
1908–9	0	......	0.7	14	2.3	6	5.3	29/30	5.4	15/16	2.0	8	0.3	9	T	1*
1909–10	T	11*	T	17	6.0	24/25	4.8	13	1.1	20/21	T	7*	2.5	25	0	......
1910–11	T	27*	1.1	30	4.0	28	1.3	5	8.4	5/6	1.8	27	2.4	2	T	1*
1911–12	T	26	0.6	14	3.3	2/3	2.5	11/12	4.2	25/26	6.4	14/15	0.1	18	0	......
1912–13	0	......	0.4	24	T	26*	1.8	6/7	4.1	25/26	2.2	21	T	4	0	......
1913–14	1.9	21	T	8/9/10	2.0	23	9.5	31	3.0	22	0.6	21/22	......	......	......	......

* Also on other dates.

the heaviest in January was 9.5 inches, in 1914. These measurements, as do all others of depth of snow in the official records, represent the snowfall on the level; that is, as it would lie were it evenly distributed over the ground. During heavy snows the wind frequently piles high drifts in some places, and sweeps other spaces bare. But these inequalities are avoided in the records by taking the average of three separate measurements at places carefully chosen (p. 216).

The data in the table cover the fall of snow for the 24-hour period, although, of course, many of the storms ceased before the full space of twenty-four hours elapsed; and some, especially the heavier ones, lasted longer than the interval taken for the record, but in practically all such cases the additional amount of snowfall was but little. The actual duration and the total fall of snow are given in Auxiliary Table G for each of the record storms in Table CV.

AUXILIARY TABLE G

HEAVIEST SNOWSTORMS ON RECORD, BY MONTHS

Date	Duration		Depth in Inches	
	Hrs.	Min.	24-Hr.	Total
November 25–26, 1895	24	40	11.5	12.0
December 12, 1903	18	38	11.3	11.3
January 31, 1914	12	27	9.5	9.5
February 18–19, 1908	29	56	12.7	12.8
March 23–24, 1897	24	50	10.0	10.0
April 11–12, 1900	32	13	2.9	3.1

The snowstorm of February 27–28, 1900, in which 11.3 inches fell, lasted 27 hours, with a total fall of 11.5 inches; while the storm of February 2–3, 1901, in which 11.4 inches fell, lasted only 10 hours. Both storms were accompanied by high winds, which resulted in much drifting and consequent interference with transportation and communication.

2. *Heavy and damaging storms of snow, sleet, and ice.*—It is desired in this connection to make some reference to the most damaging storms of snow, sleet, and ice. Sleet invariably falls in connection with snow or rain, or both, and ice storms are commonly confused with sleet storms. Sleet is frozen rain; ice storms are occasioned by rain freezing upon objects with which it comes in contact. In the former the freezing occurs before the drops strike the earth; in the latter, the cold surfaces upon which the rain falls freeze the

water into a coating of ice. Such storms cause greater damage to telegraph, telephone, and fire-alarm wires than do the heaviest snows, and as a consequence communication by such means is sometimes paralyzed, and the city even cut off from intercourse with the outside world.

November 25–26, 1895. This heavy snowstorm is listed in Table CV, but it may properly be classed as an ice storm as well, as the snow was mixed with rain freezing as it fell. Wires were coated with ice and in many portions of the city broken down, stopping communication by telephone and telegraph for an entire day, while electric-light service and street-car schedules suffered as badly. A high north to northeast wind prevailed from midnight of November 25–26 until daylight, reaching a maximum of 48 miles an hour, its force adding much to the destruction caused by weight of ice. The temperature, which was near the freezing point on the morning of the 26th, fell steadily during the day and reached 8° by the following midnight, the ensuing cold weather lengthening the period of damage by maintaining the ice coatings.

February 3–4, 1900. This storm began with a light fall of sleet turning to rain and later to heavy snow accompanied by brisk to high northerly winds. As a consequence of the wind the snow drifted badly. Streets were made very slippery and dangerous, and the condition resulted in much interruption to transportation. The temperature rose from a minimum of 18° on the 3d to a maximum of 33° at 5 P.M., falling very slowly thereafter and reaching 17° at 10 P.M. on the following day.

February 3, 1903. On this day rain, snow, and sleet began at 6 A.M., and continued until the morning of the 4th, with high northeast winds, coating all exposed objects with ice, and causing much interference to transportation and communication generally, as the storm covered a large area. The Weather Bureau anemometer was so covered with ice during this storm that an accurate record of wind velocity could not be secured. The temperature ranged from 22° to 37° on the 3d, falling steadily on the 4th and reaching a minimum of 17° by midnight.

February 29–March 1, 1908. Rain with some sleet fell from 6 P.M. of the 29th to 7:40 A.M. of March 1, causing the same general conditions noted in the above-described storms. A thunderstorm occurred in connection with this disturbance early in the morning of March 1.

February 14–15–16, 1909. Rain, snow, and sleet with a northeast gale began about midnight of the 13th, continuing through the day of the 14th, and the condition was followed by a considerable fall of snow on the 15th and 16th. The maximum velocity of the wind was 48 miles an hour on the 14th, and the storm was of more than ordinary severity, resulting in much damage. The temperature remained steadily below freezing on all three days, ranging

from 29° to 23° on the 14th, from 24° to 20° on the 15th, and from 26° to 18° on the 16th.

DECEMBER 11–12, 1909. Sleet, mixed with rain and snow, began at 7:33 P.M. of the 11th, and continued until 8:30 A.M. of the 12th, when it changed to rain with temperature a few degrees above the freezing point. As a result of the upward trend of the temperature the severity of the storm was somewhat modified, and the damage and delays were not as serious as would otherwise have been the case. Moreover, the wind velocity was not high at any time, which also tended to a minimum of damage.

JANUARY 4–5, 1910. Sleet began falling at 4:35 P.M. of the 4th, and continued until nearly midnight, in the form of small, hard pellets almost as fine as sand. The fall of sleet was 2.2 inches, but it drifted badly under brisk to high east to southeast winds. Light snow had preceded the sleet during most of the morning and afternoon, the temperature rising steadily from 1° to 22° above zero during the course of the day. During the 5th the temperature rose still farther, reaching 30° in the early morning, and falling again thereafter to 4° by midnight. With the drop in temperature the surface of the sleet solidified into a crusted stratum almost strong enough to support the weight of a man, and where the accumulation was not at once removed travel afoot for both man and animal was most difficult.

JANUARY 12–13–14, 1910. Sleet, snow, and rain fell during this storm, the rain freezing as it fell. The disturbance was in all probability the most damaging ice storm ever recorded by the local Weather Bureau office. The total snowfall was 10.2 inches. No high winds prevailed during the storm, and the temperature was moderate, ranging from 35° to 28° throughout the three days. The unusual features were due to the fact that the snow fell first and the rain afterward, saturating the former, which subsequently froze into practically solid ice. Teaming was very difficult, and freight traffic was nearly paralyzed. A coal famine was threatened, and not a milk train entered the city on the 14th, because of the impossibility of moving freight trains from their sidings in the country surrounding. Although but little snow fell during the month of February following, the conditions brought about by this storm were largely responsible for the snow covering remaining on the ground until March 10.

FEBRUARY 21, 1912. The damage by this storm was caused by high winds badly drifting the snowfall, which amounted to but 3.4 inches on the level. The snow began in the early morning with an increasing northeast wind. The wind shifted to north at about 8 A. M., and reached a velocity of 53 miles an hour at 2:06 P.M., decreasing thereafter, although it was strong throughout the afternoon and evening, and shifted to northwest about 5 P.M. The snow drifted from 3 to 4 feet deep in many places in the streets, while in other places the pavements were swept bare. As the worst part of the storm occurred during the hours of greatest business activity, delays in traffic and communication were correspondingly great. Accidents due to

the high wind and blinding snow were numerous, and although the weather cleared rapidly after the storm passed, recovery from the disastrous effects was necessarily slow.

February 26, 1912. This storm was similar to that described in the preceding paragraph, but was of somewhat lesser intensity. It, however, caused much delay to communication and transportation. The snowfall was only 4.2 inches for the whole storm, but high winds drifted it much in the streets, which became very slippery. The temperature in the morning rose to about freezing, ranging between 30° and 31° from 7 a.m. to 2 p.m., falling thereafter to a minimum of 17° at midnight.

In connection with the above storms reference may be made to severe windstorms discussed on pp. 289–92.

FREQUENCY OF SNOWFALL

The relative frequency of days with snow is shown for each month of the winter season in Table CVI, in which the record for the official period is given for all falls of 0.1 inch or more. The figures do not, of course, show all days with snow, because there are usually many days in each winter on which only an inappreciable amount ("trace") falls. The average number of days for the season is 29. The greatest number of days in any one season, 41, occurred in 1886–87, although the total depth of fall, 40.5 inches, only slightly exceeded the average. The fewest days of snow in any one season, 18, occurred in 1888–89, and the total snowfall was 22.7 inches. The actual depth of snowfall in January is exceeded by that of February (p. 216), but the frequency is somewhat less in the latter month, the averages being 8.0 days for January and 7.6 days for February. January, 1886, holds the record for the greatest number of days with snow in any one month, there being 19 days with a fall of 0.1 inch or more. In January, 1900, however, there was but 1 day on which an appreciable amount of snow fell, the amount then being only 0.3 inch, which was the total measurement for the month. In December, 1889, snow fell only in "traces." In April, 1910, snow occurred on 7 days, making a total fall of 6.9 inches, while in the warm March immediately preceding appreciable snow did not fall at any time. Fig. 49 illustrates the greatest frequency and the average monthly frequency of days with snow; also the greatest monthly amounts, the greatest fall in twenty-four consecutive hours, and the average snowfall, by months, the various data being drawn from Tables CVI, CIII, and CV.

DEPTH OF SNOW ON THE GROUND

Snow remains on the ground for a variable period. Sometimes continuous cold weather, by preventing much thawing, permits the accumulated falls to remain on the ground throughout most of the winter, while in other seasons warm spells bring about rapid melting, to be followed later by colder weather and additional snowfalls.

TABLE CVI

Monthly and Seasonal Number of Days with Snowfall of 0.1 Inch or More, 1885–1914

Season	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Season
1885–86	0	1	8	19	7	4	1	0	40
1886–87	0	4	10	12	10	5	0	0	41
1887–88	0	2	4	9	4	4	1	0	24
1888–89	0	1	4	2	8	3	0	0	18
1889–90	0	3	0	4	4	11	0	0	22
1890–91	0	0	6	7	7	7	2	0	29
1891–92	0	3	1	9	6	9	0	0	28
1892–93	0	1	8	10	9	4	2	0	34
1893–94	0	4	7	3	5	2	0	0	21
1894–95	0	1	1	11	3	3	0	0	19
1895–96	0	4	5	3	10	5	0	0	27
1896–97	0	2	4	12	8	4	2	0	32
1897–98	0	0	7	6	12	3	0	0	28
1898–99	0	4	5	6	5	6	0	0	26
1899–1900	0	0	5	1	12	8	3	0	29
1900–1901	0	2	3	5	7	8	0	0	25
1901–2	0	1	7	8	13	3	1	0	33
1902–3	0	1	10	7	7	3	2	0	30
1903–4	0	3	8	11	11	6	0	0	39
1904–5	0	0	10	11	8	2	1	0	32
1905–6	0	0	7	7	8	12	0	0	34
1906–7	0	5	2	11	5	3	3	1	30
1907–8	0	1	8	8	8	1	0	0	26
1908–9	0	2	2	6	7	3	1	0	21
1909–10	0	0	14	12	6	0	7	0	39
1910–11*	0	3	11	5	6	5	1	1	32
1911–12*	0	5	8	11	6	7	1	0	38
1912–13*	0	1	1	8	6	9	0	0	25
1913–14*	2	0	2	9	11	7	1	0	32
Means—									
1886–95	....	2.0	4.9	8.6	6.3	5.2	0.6	0	28.1
1896–1905	....	1.7	6.4	7.0	9.3	4.8	0.9	0	30.1
1886–87—1909–10	....	1.8	5.8	8.0	7.6	4.8	1.0	0.04	29.0

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Season
Average	....	1.8	5.8	8.0	7.6	4.8	1.0	....	29.0
Greatest	2	5	14	19	13	12	7	1	41
Least	0	0	0	1	3	0	0	0	18

* Not included in averages.

According to Table CVII, the greatest depth of snow on the ground at the end of January was 14.8 inches in 1885; and at the end of February, 18.3 inches in the same year, the monthly falls being 20.2 and 19.0 inches, respectively. These months were also quite cold, having a number of days with zero temperatures. As a rule, however, the depth of snow on the ground at the end of the

month cannot be taken as an indication of the amount of the snowfall, as it is possible that greater or lesser amounts may have existed

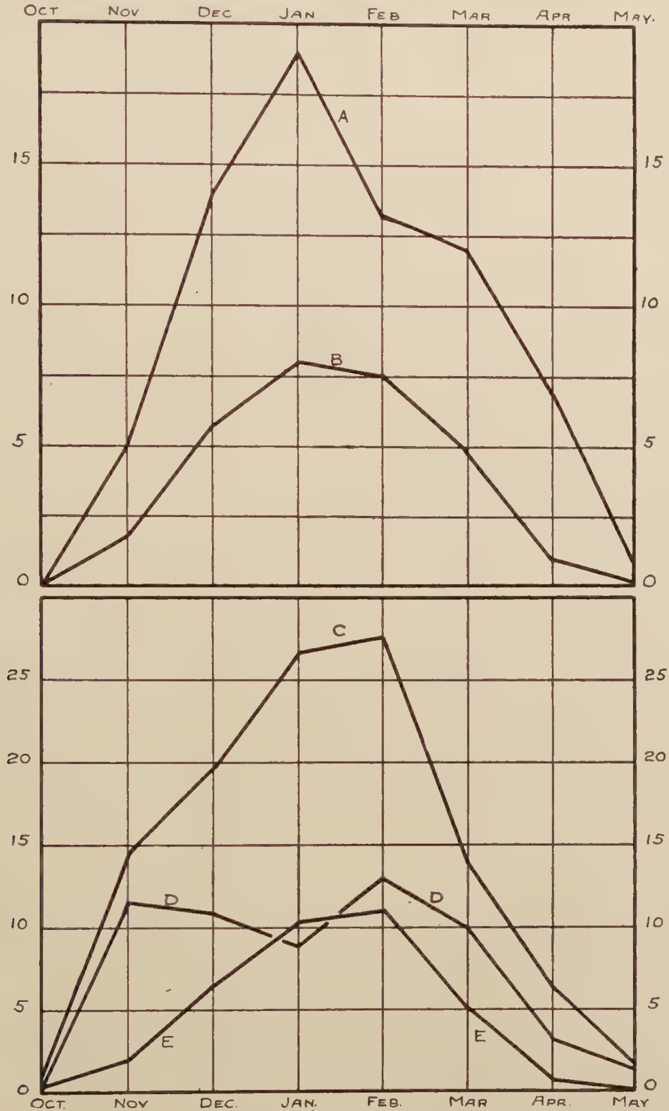


Fig. 49.—Monthly frequency and amount in inches of snowfall, 1884–85 to 1910–11.

A=greatest monthly frequency of days with snowfall; *B*=average frequency; *C*=greatest monthly amounts of snowfall; *D*=greatest snowfall in twenty-four hours; *E*=average monthly amounts of snowfall.

just before or just after that date, and not show in the record. For instance, in the winter of greatest snowfall, 1903–4, which was on the

TABLE CVII

Amount of Snow on Ground at End of Month, in Inches, 1885–1914

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1885	14.8	18.3										
1886	10.0	3.0	1.0								0.5	4.0
1887	4.5										T	1.0
1888	2.0											
1889											T	
1890		2.0	T									
1891		0.3									5.0	
1892		0.2									T	0.4
1893	2.6	0.2									2.1	
1894	3.7											5.7
1895	8.5										4.0	0.8
1896												
1897	5.0	1.0										T
1898	7.7	3.0									0.6	0.2
1899	0.4	T	T									T
1900		11.5	T									2.8
1901	3.8	2.8	T									T
1902	3.4		T									0.7
1903		T									1.0	5.6
1904	2.4	T										
1905	2.5	T									T	T
1906												
1907	3.1	T									1.6	
1908	3.1	3.7										
1909	3.8	T										9.2
1910	5.2	0.4									1.0	0.8
1911	T		T									0.6
1912	3.0	3.7	T									
1913	0.1	4.2										
1914	9.3	0.5										

whole very cold, so that the snow might be expected to remain continuously on the ground, the comparison of the monthly falls with the amounts on the ground at the end of the months shows the results given in Auxiliary Table H.

AUXILIARY TABLE H

	November	December	January	February	March
Total depth of snowfall, inches, 1903–4	2.2	18.6	11.0	13.4	14.4
Depth at end of month	1.0	5.6	2.4	trace	0.0

Table CVIII furnishes additional interesting data, the greatest amount of snow on the ground at any time during the months being entered, although the record is available only since 1893. The deepest snow covering during the period of record was 20.4 inches on February 7, 1895, a month characterized by heavy snowfalls and low temperatures, as was the month immediately preceding. The

TABLE CVIII

GREATEST DEPTH OF SNOW ON GROUND, IN INCHES, AND DATE, 1893–1914

	January		February		March		April		May		October		November		December		Annual	
	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date
1893	9.6	24	9.0	17	0.2	14	T	21	....	....	....	....	2.1	30	10.2	3, 4	10.2	Dec. 3, 4
1894	5.9	24	10.8	13	5.3	28	....	....	....	....	....	....	2.5	12	10.1	27	10.8	Feb. 13
1895	9.5	26, 27	20.4	7	5.0	4	....	....	....	....	....	....	12.0	26	4.0	2, 4	20.4	Feb. 1
1896	2.2	6	12.0	13	3.0	11	T	2	....	....	....	....	2.5	5	0.4	23	12.0	Feb. 13
1897	7.5	27, 28	3.5	1, 12	5.0	23	T	10, 16	....	....	....	....	....	....	3.0	17	7.5	Jan. 27, 28
1898	11.5	26	7.5	23	3.4	2	....	....	....	....	....	....	1.5	28	0.9	25, 26	11.5	Jan. 26
1899	0.5	23, 30	2.0	22	3.0	30	T	1	....	....	....	....	T	2, 3	2.4	14	3.0	Mar. 30
1900	T	1, 2, 13, 29, 30	11.5	28	10.8	1	1.8	11	....	....	....	....	0.8	15	2.8	31	11.5	Feb. 28
1901	4.2	30	16.0	9	3.0	30	....	....	....	....	....	....	T	27	2.4	14	16.0	Feb. 9
1902	3.4	31	5.9	11	0.1	2	T	7	....	....	....	....	T	27	1.9	7, 24	5.9	Feb. 11
1903	2.1	11	7.2	8	0.1	23, 24	0.7	3	....	....	....	....	1.3	28	10.0	12, 13	10.0	Dec. 12, 13
1904	8.0	3	6.8	21	8.0	14	T	2	....	....	....	....	....	....	4.1	13	8.0	Jan. 3 Mar. 14
1905	4.2	25	9.0	8	4.4	14	0.2	7	....	....	....	....	T	29, 30	1.8	3	9.0	Feb. 8
1906	0.5	2	3.0	15	3.6	19	....	....	....	....	....	....	1.2	12	0.2	21	3.6	Mar. 19
1907	3.2	16, 29	8.2	5	T	10, 14, 17	0.3	13	0.2	3	....	....	1.6	30	8.0	14	8.2	Feb. 5
1908	5.0	12, 13	13.5	19	3.0	1	T	2	....	....	....	....	0.7	14	1.8	6	13.5	Feb. 19
1909	4.2	30	7.4	16	T	1, 8, 16, 17, 24	T	9, 10	T	1	T	11, 12, 23, 24	T	17, 22	10.0	29, 30	10.0	Dec. 29, 30
1910	11.8	14	4.8	1	0.2	1	1.8	23	....	....	T	27, 28	1.0	30	2.1	10	11.8	Jan. 14
1911	1.4	5	7.4	6	0.7	27	2.0	2	....	....	T	26	0.4	14	3.2	3	7.4	Feb. 6
1912	5.8	14, 16	4.3	3, 5	6.2	15	T	1, 17	....	....	....	....	T	24	T	18	6.2	Mar. 15
1913	2.0	7, 10	4.2	27, 28	4.9	1	T	4	....	....	1.9	21	T	8, 9, 10	1.7	23	4.9	Mar. 1
1914	9.5	31	8.4	1	0.6	1	....	....	....	....								

next deepest covering of snow was 16.0 inches, and was measured on February 9, 1901. This month was persistently cold, although no extremely low temperatures occurred. The deepest snow on the ground during any January was on the 14th in 1910, 11.8 inches, during the winter in which the snow covering was continuous from December 5 to March 10, and the snowfalls were heavy in both December and January. Snow covered the ground that winter on a total of 100 days, 96 of these being consecutive in the period mentioned above. In the winter of 1903–4, snow covered the ground on 110 days, but, although the greatest seasonal snowfall on record occurred at that time, the periods were somewhat broken. The longest period of consecutive days with snow on the ground in this winter was 86 days, from December 7 to March 1, but the amounts varied greatly, as shown in the preceding paragraph. In the winter of 1896–97, the longest period of continuous snow covering was but 14 days, with a total of 81 days, notwithstanding the fact that considerably more than the average amount for the season fell. In the winter of 1905–6, a winter of light snowfall and comparatively high temperature, the longest period was 17 consecutive days, with a total of 82 days. On 16 of these days the depths were very little, there sometimes being but "traces" of snow in patches here and there. During the very cold winter of 1898–99, in which the total snowfall was only 18.0 inches, there were but 75 days on which the snow lay on the ground. Of these, 18 were consecutive, but on 12 of the 18 less than 0.1 inch was the amount of depth.

The greatest amount of snow on the ground occurs usually in the month of February because the heaviest snows of the year fall in the early portion of that month and the latter portion of the month preceding (p. 216).

DATES OF FIRST SNOWFALL IN AUTUMN AND LAST IN SPRING

The date of the first snowfall in autumn and the last in the following spring are given for the season of record in Table CIX. On the average the first snow of autumn occurs on October 31, and the last of spring on April 23. In 1905 and 1909 snow fell as early as October 11, and in 1902 not until November 26. The latest date in spring on which snow has fallen was June 2, 1910, when a "trace" fell during a hailstorm. The earliest date on which snow was last recorded in the spring was March 28, in 1906.

PROPORTION OF RAINFALL TO MELTED SNOWFALL

During the period of record from 1885 to 1910, inclusive, the rainfall and snowfall of the winter season, expressed in percentages

TABLE CIX

DATES OF FIRST SNOWFALL IN AUTUMN AND LAST IN SPRING, INCLUDING "TRACES" OF SNOW, 1885–1914

Year	First in Autumn	Last in Spring	Year
1885	November 1	April 1	1886
1886	November 17	April 24	1887
1887	October 21	April 20	1888
1888	October 18	May 26	1889
1889	October 30	April 9	1890
1890	October 29	May 4	1891
1891	November 13	April 9	1892
1892	November 7	April 22	1893
1893	November 15	May 18	1894
1894	November 7	May 13	1895
1895	October 20	April 2	1896
1896	October 17	April 16	1897
1897	November 2	April 5	1898
1898	October 14	April 15	1899
1899	November 2	April 13	1900
1900	November 6	April 21	1901
1901	November 3	May 10	1902
1902	November 26	April 30	1903
1903	November 5	April 16	1904
1904	October 22	April 16	1905
1905	October 11	March 28	1906
1906	November 10	May 10	1907
1907	November 10	April 2	1908
1908	November 4	May 2	1909
1909	October 11	June 2	1910
1910	October 26	May 2	1911*
1911*	October 26	April 18	1912*
1912*	November 1	April 4	1913*
1913*	October 20	April 20	1914*
Earliest	October 11, 1905 and 1909	March 28, 1906	
Latest	November 26, 1902	June 2, 1910	
Average	October 31	April 23	

* Not included in average.

of the total monthly and seasonal precipitation, has been as given in Auxiliary Table I. Of the total annual precipitation, 12 per cent, or about one-eighth, falls as snow.

AUXILIARY TABLE I

PERCENTAGE OF PRECIPITATION OCCURRING AS RAIN AND MELTED SNOW

	Rainfall	Snowfall
	Percentage	Percentage
November	91	9
December	68	32
January	53	47
February	50	50
March	78	22
April	96	4
Season	72.7	27.3

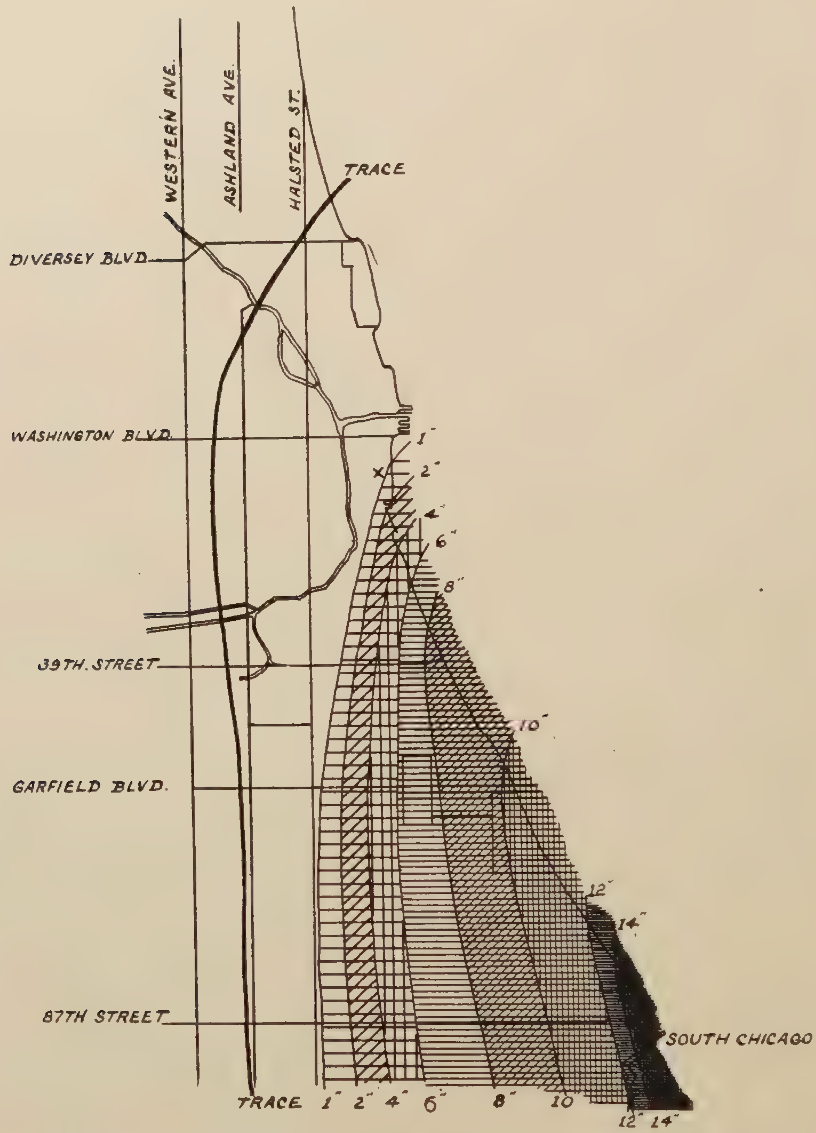


Fig. 50.

Fig. 50 shows the estimated snowfall in the city of Chicago on Thanksgiving Day, November 26, 1903, during a freak snowstorm in which 14 inches fell in South Chicago, near the lake, and practically none at all west of Halsted Street.

DISTRIBUTION OF SNOWFALL IN THE CITY

While the measurement of snowfall is made at the Weather Office and in Grant Park, near the lake, as has been indicated, for some time it has been the practice of the official observers to make notes of the depths of snow in the respective localities in which they reside. Ordinarily there is no great variation in the amount of snowfall throughout the city, but occasionally, because of peculiar local conditions, wide differences have been observed. One of the most remarkable occurrences of this character happened in connection

TABLE CX

SUMMARY OF SNOWFALL DATA

	Means		Greatest Monthly Amounts			Number of Days with Snow						Greatest Snowfall in Twenty-four Hours	
			1884–1913			1885–1910						1891–1914	
						Omitting Traces			Including Traces				
	Mean Snowfall, 1884–1910	As percentage of Precipitation	Amount	Year	Percentage of Mean	Average	Greatest	Least	Average	Greatest	Least	Amount	Year
October...	T	......	1.9	1913	......	0	0	0	0.9	4	0	1.9	1913
November	2.2	9	14.5	1895	659	1.8	5	0	5.7	13	2	11.5	1895
December..	6.8	32	19.1	1909	281	5.8	14	0	12.6	20	3	11.3	1903
January...	10.2	47	26.7	1886	262	8.0	19	1	13.3	20	4	9.5	1914
February..	11.3	50	27.8	1896	246	7.6	13	3	12.6	20	8	12.7	1908
March.....	5.0	22	14.3	1904	286	4.8	12	0	10.3	19	2	10.0	1897
April.....	1.0	4	6.9	1910	690	1.0	7	0	3.0	8	0	2.9	1900
May......	0.1	......	1.3	1907	......	0	1	0	0.4	3	0	1.3	1907
Seasonal ..	36.2	......	59.5	1903–4	163	29.0	41 in 1886–87	18 in 1888–89	58.8	84 in 1903–4	40 in 1889–90	12.7	1908 in Feb.

The various records on which the above table is based were begun at different times. Hence the data do not cover exactly the same periods.

with the snowstorm of Thanksgiving Day, November 26, 1903, and Fig. 50 has been prepared to show the distribution of snowfall throughout the city at that time. There was practically no snowfall west of Halsted Street or in the sections lying north of the river. The amount increased from the south branch of the river eastward to the lake, and southward through the limits of the city, reaching a maximum depth of 14 inches at South Chicago. While snow was falling over the South Side the sun was shining brightly throughout the western sections. The general distribution of atmospheric pressure was such as to cause a brisk north wind at the southern end

of Lake Michigan. The day was cold for the season, with temperature ranging from 13° to 20°, but the temperature of the water surface was, of course, considerably above the freezing point. A north wind at Chicago skirts the shore of the northern portions of the city, but, as the shore to the southward trends farther and farther to the southeast, a wind from the north produces more and more of the lake effect (p. 216). In this case the temperature over the land was such that the moisture carried on shore by the wind was soon chilled to the point of condensation, and heavy snow resulted in the southern sections. In Grant Park the fall was but 0.6 inch, while at Jackson Park 10 inches were measured, the depth increasing thence southward as above indicated.

SUMMARY OF SNOWFALL DATA

Table CX presents the main features of the data on snowfall in a manner similar to that used for the summary of precipitation data (Table XCIX), and will be found valuable for purposes of reference.

PART III

ATMOSPHERIC MOISTURE

ATMOSPHERIC MOISTURE

The term *humidity* has reference to the quantity of moisture present in the air at all times in the state of invisible vapor. The air is said to be dry when but little is present, and humid when the quantity is relatively considerable. If the quantity of moisture is measured as weight per unit of volume, as, for example, grains per cubic foot, the numerical value is designated the absolute humidity. If, however, as is most common in statistics relating to weather and climate, the measurement is expressed as a percentage of the quantity of vapor that can possibly exist at the temperature in question, then the numerical value is called the relative humidity.

The conditions of humidity have at times fully as much to do with comfort and salubrity as do those of temperature, sunshine, and wind. Paradoxical as it may seem, a high degree of humidity makes a hot wave sensibly hotter, and a cold wave colder, than is the case when the amount of moisture in the air is relatively low. High humidity in warm weather, by materially retarding the evaporation of perspiration from the pores of the body, prevents the cooling produced by this process in other heated periods. On the other hand, during times of cold weather, by penetrating the clothing and communicating dampness to it, an atmosphere with high humidity increases the conductive qualities of the fabric and permits a more rapid escape of the body's heat. The disagreeable features of damp climates, whether warm or cold, and the comparative pleasantness of regions in which the atmosphere has a low percentage of moisture are well known. Residents of the foothills along the eastern sides of the Rockies, and those of the dry sections of the interior Northwest, experience temperatures of zero and below with less discomfort than even much higher winter temperatures bring to localities of greater relative humidity; and the heat of many arid regions is rendered less oppressive by the extreme dryness of the air, while very moist climates are enervating at temperatures but little above the average.

It is common to speak of the moisture content of the atmosphere, or of the capacity of the air for water vapor; but as a matter of fact, the presence of air has little to do with the volume of water in the form of vapor within any given space. This vapor exists practically

independent of the other gases of the air, and its mass per volume depends upon the temperature. Whenever, therefore, the expressions "capacity of the air for moisture" and "moisture content of the air" are used herein, the distinction noted must be kept in mind.

This so-called capacity of the air for moisture in the form of vapor increases rapidly with rising temperature. A cubic foot of air at 32° will, if saturated, contain about 2 grains of aqueous vapor; at 50° the same volume will have a capacity of about 4 grains; at 70°, about 8 grains, and at 100°, about 20 grains. If the quantity of water vapor in any free volume of air at 32° is actually 2 grains to the cubic foot, the relative humidity is 100 per cent. Now if, as may be the case in nature, the temperature rises while the actual amount of moisture to the cubic foot remains the same, the relative humidity at 50° becomes only 50 per cent, because 4 grains is the capacity at that temperature; at 70° it has fallen to 25 per cent, and at 100° the relative humidity would be about 10 per cent. In the first instance the air would be saturated with water vapor and no more could be taken up; in the last, it would be extremely dry, as it sometimes becomes in the desert regions of the arid Southwest, and any water surface exposed to such an atmosphere would evaporate rapidly.

RELATIVE HUMIDITY, MONTHLY AND ANNUAL

The average relative humidity, based upon readings of the psychrometer made at 7 o'clock each morning and evening, is shown for the period of record in Table CXI. Prior to 1889 the observations were made at different hours, and those readings are therefore not comparable with the figures in the table, which are all that are available for any period of sufficient length to afford means of any special significance.

The mean annual relative humidity at Chicago is 75.3 per cent, and the yearly averages have ranged from 80.2 per cent in 1900 to 68.5 per cent in 1895. As a rule, relative humidity is highest during cloudy and rainy weather, and lowest during clear weather with bright sunshine and strong southwest winds. The lake wind is always laden with moisture, but in the summer and late spring its relative humidity is not so high as in other seasons, because its capacity is increasing with the rise in temperature of its current as it sweeps over the warmer land. The conditions just pointed out, however, are not always apparent in the average readings. For

instance, in 1900, the year of highest average relative humidity, the total precipitation was but 28.65 inches, considerably below the normal; in 1895, the year of lowest relative humidity, while the total precipitation, 32.38 inches, was below the normal, it was greater than that of 1900 by more than 3 inches.

The means for the various months, shown at the bottom of the table, give considerably higher relative humidity for the winter months than for the summer season, ranging from 82.3 per cent in January to 70.4 per cent in July. These figures indicate a closer

TABLE CXI

Mean Monthly Relative Humidity, Per Cent, 1889–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1889	82	82	76	76	71	79	72	66	69	70	83	76	75.2
1890	81	82	74	72	71	73	64	74	76	82	73	76	74.8
1891	82	80	84	75	66	81	70	74	66	66	79	77	75.0
1892	82	85	76	68	80	84	72	72	70	66	78	83	76.3
1893	88	84	80	77	74	74	72	66	66	70	76	83	75.8
1894	80	80	74	72	72	60	56	64	70	71	72	78	70.8
1895	81	81	68	71	64	60	62	62	65	58	72	78	68.5
1896	80	76	70	67	62	68	68	66	72	69	80	81	71.6
1897	83	80	82	77	66	72	72	70	62	66	74	84	74.0
1898	86	84	77	70	76	72	67	73	72	82	78	86	76.9
1899	82	80	81	68	73	73	81	84	71	74	81	78	77.2
1900	84	83	84	74	70	77	82	82	82	84	80	80	80.2
1901	83	85	86	76	83	78	68	76	75	72	76	85	78.6
1902	77	85	80	69	74	78	79	78	78	75	80	86	78.2
1903	84	84	85	75	72	70	70	76	69	70	71	84	75.8
1904	85	83	82	72	69	72	68	69	78	72	70	79	74.9
1905	82	84	82	77	78	77	74	73	72	69	76	78	76.8
1906	82	80	80	76	72	72	72	76	74	75	76	83	76.5
1907	86	77	78	72	73	74	73	74	76	77	71	82	76.1
1908	80	79	74	74	81	70	75	67	74	73	80	74	75.1
1909	81	80	74	74	74	77	65	75	78	71	73	84	75.5
1910	79	74	66	74	74	66	67	69	78	76	75	76	72.5
1911*	79	77	69	73	62	67	59	70	78	76	76	78	72.0
1912*	72	74	75	70	70	65	73	78	72	69	68	68	71.2
1913*	75	67	71	64	68	62	67	72	72	76	73	76	70.2
Means	82.3	81.3	77.9	73.0	72.5	73.1	70.4	72.1	72.4	72.2	76.1	80.5	75.3

* Not included in means.

relation between the frequency of precipitation and relative humidity than exists between the latter and the actual amount of rainfall and snowfall, as expressed in average values. Precipitation is most frequent in the winter season (p. 168), and relative humidity is on the average highest at that time; precipitation is heaviest during the summer (p. 157), at which time relative humidity is on the average at its lowest. The high values of the averages for the colder portion of the year are not due to greater amounts of moisture in the air. As a matter of fact, the absolute humidity for the winter is much less than for the summer, but in periods of low temperature a turn

to slightly colder weather raises the relative humidity greatly, because of the very much smaller capacity of the air for moisture at that season.

The average values for mean relative humidity shown in Table CXI, based as they are upon observations taken at 7 A.M. and 7 P.M., are somewhat higher than the mean observations taken at each of the twenty-four hours of the day would give, and also slightly higher than the mean obtained from the maximum and minimum relative humidity of the successive days. This excess is due to the fact that both observations of the day come at a time when the daytime effect of the sun's heat in lowering relative humidity is felt but little in the summer season, and not at all in the winter months. The first observation is near the time of maximum relative humidity, and the second long after the time of minimum, so that the latter observation is much too high to produce a true mean when combined with the former. Since May, 1911, bi-hourly values of relative humidity, as recorded by a hygrograph, have been secured for each day, and these records for the year following, given in Table CXII, will illustrate the truth of the foregoing statements. The average of the bi-hourly readings (*a*) for each month will be found in each case to be lower than the averages of the 7 A.M. and 7 P.M. observations (*b*), the difference for the year being 1.6 per cent. The highest hourly average for the period given, 76.5 per cent, occurred at 6 A.M., and the lowest, 62.5 per cent, at 2 P.M,. the average of these two readings being 69.5 per cent, only three-tenths of 1 per cent below the average of the bi-hourly values.

Fig. 51 shows graphically the mean relative humidity and the mean temperature of the months from May, 1911, to April, 1912, inclusive, based upon observations at the bi-hourly times shown in Table CXII. The general condition of higher relative humidity during the season of low temperatures (p. 241) is plainly to be seen in the graph, but the average temperature of any particular month can in nowise be taken as a certain index of the percentage of atmospheric moisture. For instance, January, 1912, was the coldest January of the official record, and we might therefore expect the relative humidity to be correspondingly high. Its mean, however, was about 10 per cent lower than the average for that month of the year and, while higher than that of the previous summer season, was considerably below the readings of December, 1911, and February, 1912, each of which was marked by higher temperature. The relation of temperature

and relative humidity is closest for short periods of change, and little dependence can be placed upon the relation of average values for individual months. The relative humidity of January, 1912, lower

TABLE CXII

RELATIVE HUMIDITY AND TEMPERATURE, MAY, 1911, TO APRIL, 1912

HUMIDITY, PER CENT

		2:00 A.M.	4:00 A.M.	6:00 A.M.	8:00 A.M.	10:00 A.M.	NOON	2:00 P.M.	4:00 P.M.	6:00 P.M.	8:00 P.M.	10:00 P.M.	MIDNIGHT	Average (*a*)	Average (*b*)
1911	May	66.0	68.4	69.0	64.1	54.9	53.3	50.4	52.3	54.8	59.5	62.1	64.7	59.1	62.4
	June	73.3	75.0	73.3	68.6	64.4	59.7	50.4	56.5	59.8	65.6	68.4	70.7	65.5	66.8
	July	64.8	67.5	66.8	59.5	51.6	51.4	51.0	51.4	52.4	58.9	60.9	63.6	58.3	59.4
	August	73.2	75.8	77.4	72.8	66.6	63.9	61.5	62.5	63.2	66.8	69.0	70.2	68.6	70.2
	September	79.3	80.2	82.5	78.2	72.9	69.6	68.2	71.6	74.5	76.2	76.9	79.3	75.8	78.0
	October	77.9	78.2	79.4	77.4	73.0	69.3	67.8	69.6	72.7	74.6	74.5	75.5	74.2	76.1
	November	77.3	77.5	79.0	78.4	73.3	68.1	67.0	67.5	70.8	73.3	75.8	78.2	73.8	75.5
	December	81.0	80.6	81.8	81.6	77.8	75.2	70.5	70.2	72.5	76.2	78.5	80.1	77.2	77.6
1912	January	69.7	73.2	77.4	75.6	72.2	68.7	65.8	67.5	69.3	69.4	69.4	69.8	70.7	72.0
	February	76.9	76.7	77.7	77.9	75.0	71.8	67.9	67.4	70.0	72.3	73.1	74.6	73.4	74.4
	March	74.2	75.3	77.4	76.3	71.6	69.9	69.0	67.5	70.7	73.4	74.2	73.9	72.8	74.6
	April	72.0	74.8	76.0	71.7	67.2	63.9	60.8	60.0	62.3	66.1	68.4	71.2	67.9	69.6
Average		73.8	75.3	76.5	73.5	68.4	65.4	62.5	63.7	66.1	69.4	70.9	72.6	69.8	71.4

TEMPERATURE, DEGREES

		2:00 A.M.	4:00 A.M.	6:00 A.M.	8:00 A.M.	10:00 A.M.	NOON	2:00 P.M.	4:00 P.M.	6:00 P.M.	8:00 P.M.	10:00 P.M.	MIDNIGHT	Average (*a*)	Average (*b*)
1911	May	61.6	59.8	60.1	64.5	69.1	70.8	71.6	70.9	68.4	65.5	64.4	63.1	65.8	64.2
	June	68.3	67.0	66.9	70.4	73.3	76.4	77.1	77.1	76.0	72.7	71.2	70.5	72.2	71.8
	July	71.6	70.3	70.1	74.5	78.4	80.0	80.1	80.3	80.0	77.2	75.3	73.6	76.0	75.6
	August	69.0	67.4	66.6	69.6	72.3	73.7	74.6	74.7	74.5	72.3	71.2	70.1	71.3	70.8
	September	64.8	63.8	62.9	64.6	67.4	69.1	69.9	69.4	68.6	67.8	67.0	65.6	66.7	65.8
	October	51.3	50.4	50.0	50.8	53.8	55.7	56.9	56.5	54.9	53.7	52.4	51.5	53.2	52.4
	November	33.7	33.2	32.6	33.0	35.4	37.7	38.9	38.6	37.5	36.2	35.0	34.1	35.5	34.8
	December	33.5	33.3	32.9	32.6	34.3	35.7	37.3	37.8	37.1	35.8	34.7	33.8	34.9	34.7
1912	January	9.3	9.2	9.0	9.5	11.5	14.1	16.4	16.6	14.9	13.5	12.0	11.5	12.3	12.1
	February	20.4	19.8	19.0	19.1	21.3	23.2	24.7	24.8	23.8	22.7	21.6	20.6	21.8	21.4
	March	26.3	25.5	25.1	26.7	29.2	30.5	31.9	32.1	30.8	29.6	28.7	28.0	28.7	28.2
	April	44.9	44.3	44.0	46.5	49.8	51.9	53.6	54.0	52.0	49.8	47.6	46.6	48.8	48.0
Average		46.2	45.3	44.9	46.8	49.6	51.6	52.8	52.7	51.5	49.7	48.4	47.4	48.9	48.3

Table CXII contains a bi-hourly record of the relative humidity and temperature for a single year from May, 1911, to April, 1912. The humidity readings are taken from the hygrograph and the temperature readings from a thermograph. Average (*a*) is the average of the bi-hourly readings, while average (*b*) is that of the two regular observation hours, 7:00 A.M. and 7:00 P.M., at which time the relative humidity is taken from the whirling psychrometer, and the temperature from the official thermometers (see Fig. 52).

than that of the preceding or the following month, was the result of the extraordinarily large number of bright, sunshiny days, which are common to extended periods of very cold weather.

RELATIVE HUMIDITY, HOURLY

Unfortunately, no hourly relative humidity readings for Chicago are available, and the period of bi-hourly values shown in Table CXII is much too short to establish with any degree of accuracy

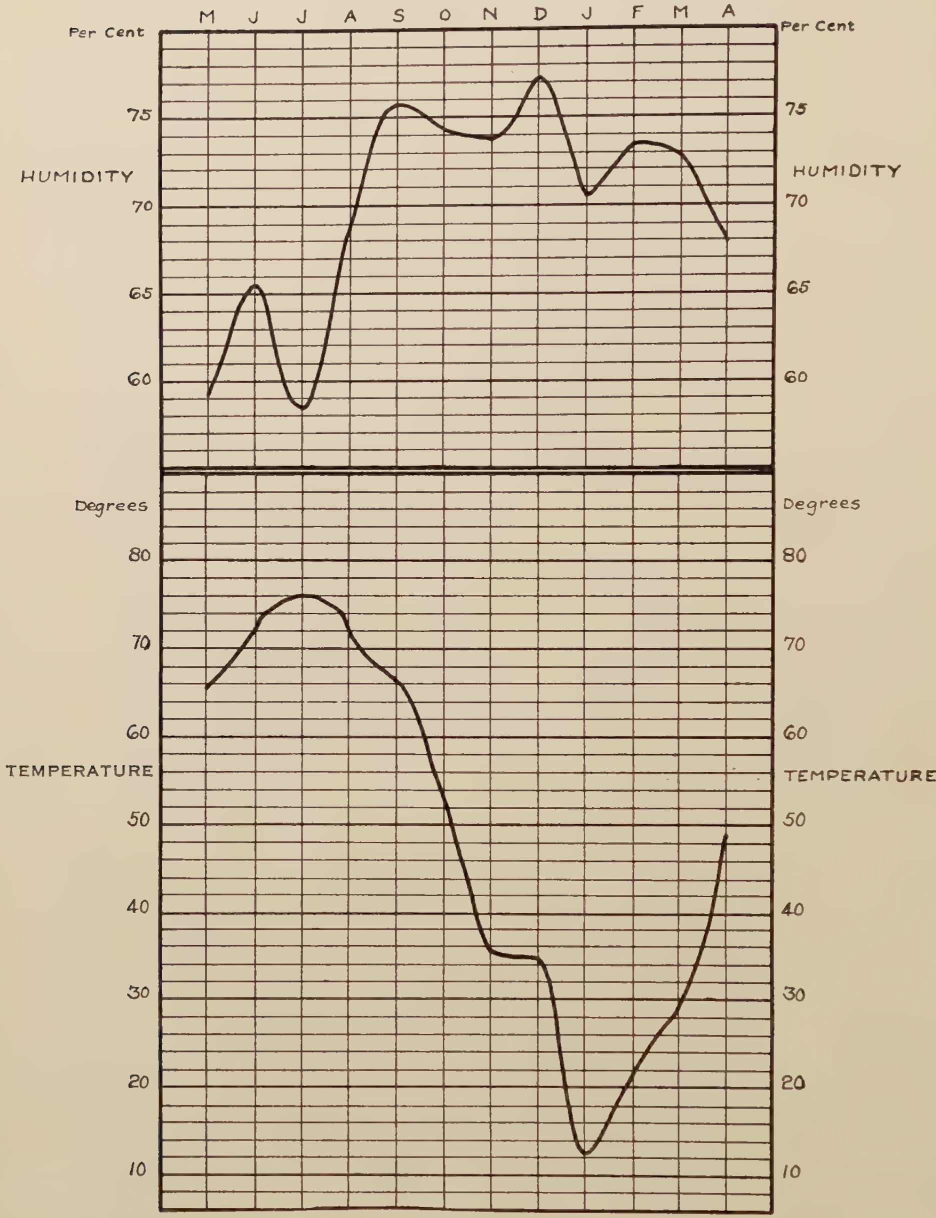


Fig. 51.

Average relative humidity by months, from May, 1911, to April, 1912, inclusive.
Average temperature by months, from May, 1911, to April, 1912, inclusive.

(See Table CXII)

mean relative humidities for the various hours. Temporary irregularities due to storm movement are too numerous to warrant many generalities in this connection. For instance, the bi-hourly averages of July, 1911, and of July, 1912, show great differences (Auxiliary Table J).

AUXILIARY TABLE J

COMPARISON OF BI-HOURLY RELATIVE HUMIDITY, JULY, 1911, AND JULY, 1912

	2 A.M.	4 A.M.	6 A.M.	8 A.M.	10 A.M.	12 M.	2 P.M.	4 P.M.	6 P.M.	8 P.M.	10 P.M.	12 MDT.
July, 1911	65	68	67	60	52	51	51	51	52	60	61	64
July, 1912	78	79	80	75	70	68	66	64	68	71	74	76

Monthly averages: July, 1911, 58.3 per cent; July, 1912, 72.4 per cent.

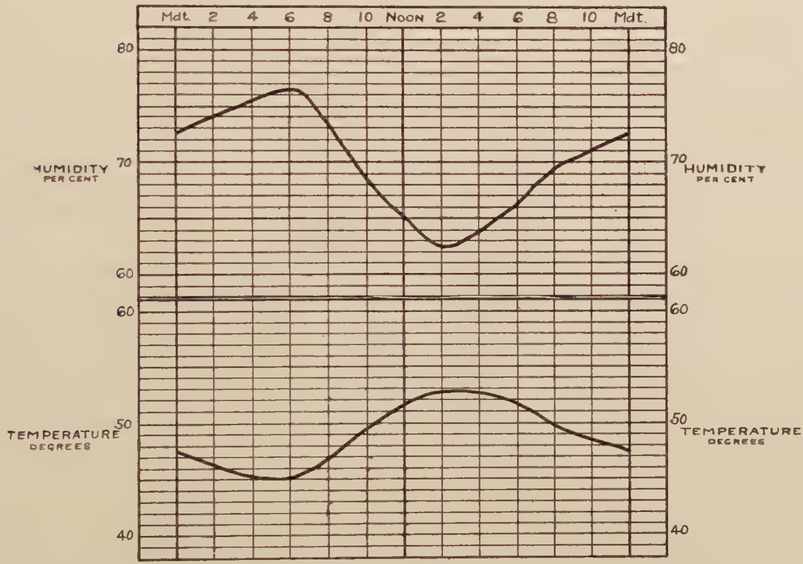


FIG. 52.—Relative humidity (bi-hourly) from May, 1911, to April, 1912, inclusive; temperature (bi-hourly) from May, 1911, to April, 1912, inclusive.

However, the relation in short periods of temperature and relative humidity, and the average cycle of changes during the hours of the day, are apparent from the means at the bottom of each section of the table. The relation and change is nicely illustrated in Fig. 52. For any short period of time the actual amount of water vapor in the

air may be considered as fairly constant, and the effect of rising temperature in increasing the capacity of the air for moisture is therefore to lower the relative humidity; and the converse is equally true. As a result, the air is most humid at about the time of minimum temperature and driest at or just before the occurrence of the maximum temperature; that is, at about 6 A.M. and 3 P.M., respectively (p. 136).

On individual days relative humidity follows closely the changes in temperature, cloudiness, and shift of wind, and usually rises decidedly upon the approach of rain or snow. On May 7, 1911, relative humidity was remarkably low throughout the day, the bi-hourly readings, beginning with 2 A.M., being 48, 49, 49, 43, 34, 27, 24, 23, 24, 30, 36, and 39 per cent, respectively. This day was clear during the entire twenty-four hours, with bright sunshine from sunrise to sunset, and with a moderate southwesterly wind. The temperature rose rapidly from 55° at 5 A.M. to the maximum for the day, 77°, at 3 P.M. On August 13, 1911, the bi-hourly relative humidity, beginning with 2 A.M., was 93, 94, 95, 89, 90, 96, 92, 93, 96, 94, 86, and 87 per cent. The temperature was quite uniform, ranging only 6°, from 68° in the early morning to 74° at the following midnight. Rain began shortly after 12 A.M., ending at 6:13 A.M., but two short showers occurred between 11 A.M. and 1 P.M. The weather was cloudy during the morning and early afternoon, the clouds breaking somewhat thereafter. Between 8 and 11 o'clock in the morning the sun shone through rifts in the clouds, which explains the temporary drop in relative humidity at that time, and there was in like manner sunshine during the afternoon. Owing to the nearly stationary temperature, however, and the evaporation from moist surfaces, the sunshine was not as effective in reducing the relative humidity as would otherwise have been the case.

Relative humidity of 100 per cent, or complete saturation, is not uncommon in cloudy, wet weather, especially if foggy conditions prevail. There is no instance on record, however, of such state continuing throughout the entire period of any one day. Occasionally extremely low relative humidity is experienced. On October 21, 1871, with a temperature of 71°, the relative humidity at 3 P.M. was 20 per cent; and on April 25, 1872, with a temperature of 81°, the relative humidity at the same hour was 19 per cent. As far as known, the latter is the lowest relative humidity reading ever occurring at Chicago.

COMPARISON OF RELATIVE HUMIDITY AT CHICAGO WITH THAT OF OTHER PORTIONS OF THE UNITED STATES

Table CXIII and Fig. 53 contain the average monthly and annual relative humidity for the same cities in the United States that were used in the comparison of monthly and annual precipitation (p. 165, Fig. 36). The highest relative humidity is, as we should expect, along the Pacific coast, where the prevailing winds are from the ocean, and along the southern coasts from Texas eastward, where the warm air is laden with moisture from the Gulf Stream. San Francisco, Cal., has the same annual percentage as Jacksonville, Fla., 80 per cent, although the precipitation of the former is but about

TABLE CXIII

Mean Monthly and Annual Relative Humidity in Per Cent for 15 Selected Cities, 1889–1910

(See Fig. 53)

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Portland, Ore........	88	86	86	85	85	84	84	86	88	90	89	88	87
San Francisco, Cal....	81	79	77	75	79	83	87	86	80	78	78	78	80
Yuma, Ariz..........	44	45	42	38	38	38	43	48	45	44	44	46	43
Havre, Mont........	80	82	76	62	63	62	56	56	62	68	75	79	69
Denver, Colo........	56	56	53	50	54	50	48	50	47	49	53	53	51
El Paso, Tex.........	47	40	30	26	24	29	46	48	48	46	47	48	40
Moorhead, Minn.....	88	87	85	75	68	73	74	74	75	77	85	88	80
Omaha, Neb.........	76	76	70	62	64	68	68	70	69	66	70	76	70
Galveston, Tex.......	84	85	86	83	80	79	78	78	77	76	81	82	81
Marquette, Mich.....	82	81	79	73	71	71	72	75	77	77	80	81	77
Chicago, Ill..........	82	81	80	73	72	73	70	72	72	72	76	80	75
New Orleans, La......	78	78	78	76	76	78	79	79	79	76	78	79	78
Northfield, Vt........	80	76	76	71	72	76	78	83	88	81	80	81	78
New York, N.Y......	74	72	71	68	71	73	73	75	76	73	73	73	73
Jacksonville, Fla......	81	79	78	74	76	78	80	82	84	82	82	81	80

two-fifths of that of the southern city. Yuma, Ariz., in the midst of the arid region with its cloudless skies, has an annual percentage of 43, while El Paso, Tex., in the foothills farther to the east and with three times the rainfall, has an average of but 40 per cent. At El Paso, however, the spring months are exceptionally dry; while at Yuma, although daytime temperatures cause extremely low humidity during the afternoons, clear skies and still atmosphere at night permit radiation to bring the temperature relatively low, and so raise somewhat the percentage of moisture. Denver, Colo., at an altitude of about 5,000 feet, has a low annual average, because the crests of the Rockies to the west rob the prevailing westerlies of moisture before reaching the city. In regard to the other cities shown, the

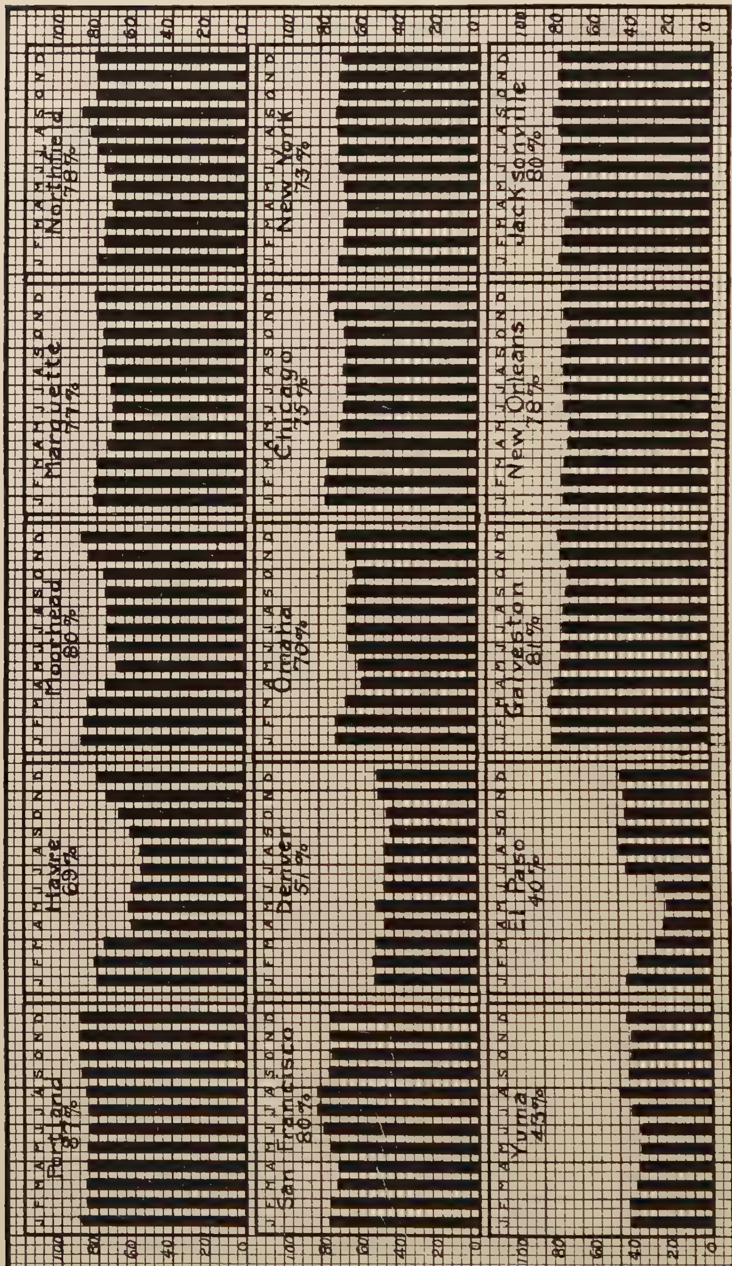


FIG. 53.—Average monthly and annual relative humidity in per cent for 15 selected cities, 1889–1910. These values are also shown in Table CXIII.

values also depend largely upon location, prevailing wind direction, temperature, and proximity to water surfaces.

DEW POINT

Whenever the relative humidity is 100 per cent, that is, when the air is saturated with vapor of water, condensation must begin with any lowering of the temperature. Whenever the relative humidity is less than 100 per cent, the temperature to which the air must fall

TABLE CXIV

MEAN MONTHLY AND ANNUAL DEW-POINT, DEGREES, 1889–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1889........	24	14	29	37	45	54	60	57	51	39	33	33	40
1890........	26	26	21	35	42	60	58	57	52	45	32	23	40
1891........	24	22	25	38	41	58	56	59	55	39	27	28	39
1892........	14	26	23	33	46	59	51	61	52	41	28	19	39
1893	10	18	27	36	44	58	64	57	50	42	28	22	38
1894........	23	18	33	37	46	55	55	56	54	42	26	26	39
1895........	13	12	22	36	46	54	56	57	55	31	28	24	36
1896........	22	20	22	41	51	55	60	60	50	38	32	27	40
1897........	18	24	29	37	42	54	64	58	54	45	31	21	40
1898........	25	23	33	34	47	59	61	62	56	45	29	20	41
1899........	19	12	24	39	48	60	65	68	51	48	38	21	41
1900........	23	16	24	37	47	55	65	69	59	54	32	24	42
1901........	21	13	29	37	47	61	64	62	54	44	30	20	40
1902........	19	17	32	35	49	55	65	60	52	45	40	23	41
1903........	20	21	35	38	48	50	60	59	52	42	27	16	39
1904........	14	13	29	31	45	53	58	56	55	42	32	22	38
1905	14	13	33	37	48	56	61	63	56	41	33	26	40
1906........	28	22	24	41	49	57	61	65	60	44	34	28	43
1907........	24	20	35	31	42	56	63	60	55	44	31	28	41
1908........	23	21	31	39	52	58	65	60	60	45	36	24	43
1909........	24	27	28	36	46	57	59	65	56	40	41	18	41
1910	20	18	36	40	44	55	62	61	58	48	28	20	41
1911*.......	23	26	28	37	50	59	60	60	58	45	28	29	42
1912*.......	5	15	22	38	48	52	62	62	56	44	33	24	38
1913*.......	23	15	26	36	46	56	62	63	55	44	38	30	41
Means......	20	19	28	36	46	56	61	60	54	43	32	23	40

* Not included in means.

to produce saturation and condensation is called the "dew point." The monthly and annual values of the dew point at Chicago are entered in Table CXIV. No discussion of the subject is necessary beyond calling attention to the fact that, during the period from April to October, inclusive, the mean dew point is below the mean temperature by about 10°; in February, March, November, and December, by about 6° to 7°, while the depression is least in January, averaging then about 4° (Table I).

PART IV

CLOUDINESS AND SUNSHINE

CLOUDINESS AND SUNSHINE

AVERAGE CLOUDINESS, MONTHLY AND ANNUAL

Table CXV shows the average cloudiness by months and years from 1890 to 1913, inclusive. These figures are based upon observations made between sunrise and sunset only, and are determined upon a scale of 0 to 10, 0 representing total absence of clouds, and 10 the condition of cloudiness which would obscure every portion of the

TABLE CXV

MEAN MONTHLY AND ANNUAL CLOUDINESS, 1890–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1890........	5.9	6.5	5.1	4.6	6.1	5.1	3.5	4.7	5.1	7.0	5.3	5.3	5.4
1891........	7.1	5.5	7.7	5.2	4.1	5.6	3.9	4.7	2.2	4.3	7.2	5.2	5.2
1892........	5.6	7.3	5.8	6.3	6.8	7.2	4.4	4.5	4.0	4.3	6.6	6.6	5.8
1893........	6.9	6.1	6.9	6.9	5.5	4.6	3.1	3.1	4.4	4.1	5.2	6.1	5.2
1894........	5.8	5.0	5.2	4.9	5.0	4.2	1.9	4.6	4.0	5.9	6.5	5.6	4.9
1895........	5.8	4.1	4.0	4.4	3.8	3.0	3.7	3.3	2.9	3.5	6.9	7.4	4.4
1896........	7.0	5.3	4.6	4.6	3.4	3.7	4.2	3.1	5.5	4.5	6.4	7.2	5.0
1897........	6.3	7.1	5.4	5.4	4.3	5.3	4.1	4.5	2.9	2.9	6.9	6.9	5.2
1898........	5.2	5.7	4.4	4.6	4.4	5.0	2.3	3.7	4.2	7.4	5.6	5.3	4.8
1899........	5.5	6.0	7.4	4.2	5.1	3.7	4.5	3.4	5.4	5.3	6.5	6.3	5.3
1900........	6.4	5.8	6.2	4.7	5.0	4.5	4.5	4.5	4.8	4.3	6.1	6.4	5.3
1901........	6.5	3.8	7.0	4.5	5.9	3.7	3.2	4.9	4.0	3.6	5.6	6.7	5.0
1902........	5.0	4.7	6.1	5.2	4.4	5.4	4.7	4.0	5.8	4.4	6.1	7.0	5.2
1903........	6.3	5.5	5.7	5.7	5.6	5.6	4.5	6.0	4.7	4.0	5.2	6.1	5.4
1904........	6.5	7.1	7.5	5.7	5.9	4.8	5.1	4.3	6.1	5.0	5.4	7.3	5.9
1905........	6.4	5.4	6.5	5.8	5.4	5.0	6.2	5.3	5.5	5.5	5.4	5.2	5.6
1906........	6.6	5.8	6.8	4.8	5.2	4.8	4.4	4.9	4.3	6.4	6.7	7.7	5.7
1907........	7.6	5.7	6.5	6.6	6.0	4.9	5.8	4.6	6.1	5.3	4.6	7.4	5.9
1908........	5.2	6.9	6.3	5.6	6.2	3.9	4.5	3.6	2.8	4.4	5.5	6.3	5.1
1909........	7.7	7.8	6.7	6.6	4.8	6.2	5.5	4.0	4.9	5.2	6.8	6.8	6.1
1910........	7.5	6.6	3.2	5.4	5.5	3.2	4.2	5.0	5.1	3.9	6.7	6.2	5.2
1911*.......	7.9	6.3	5.2	5.9	4.2	4.4	3.8	4.5	5.5	6.8	6.5	6.1	5.6
1912*.......	6.2	6.0	6.1	4.9	5.4	3.9	5.2	5.5	4.6	3.9	5.0	5.5	5.2
1913*.......	7.1	5.0	6.4	5.0	5.7	3.6	3.6	4.7	4.6	5.3	6.4	6.6	5.3
Means......	6.3	5.9	6.0	4.9	5.2	4.7	4.2	4.3	4.5	4.8	6.1	6.4	5.3

* Not included in means.

Table CXV contains the average cloudiness by months and years from 1890 to 1913, based upon observations made between sunrise and sunset, on a scale of from 0 to 10, 0 representing total absence of clouds, and 10 representing total cloudiness, that is, when the sky is entirely overcast.

sky above the horizon. The average for the entire period is 5.3. This may be understood in two ways: that on the average the sky is totally clouded for a little more than half the time, or that somewhat more than half the sky is clouded during the whole time from sunrise to sunset. The proportions vary from month to month and from year to year, the greatest annual cloudiness being in 1909, a wet year, with an average of 6.1; and the least in 1895, a year of

nearly normal precipitation and of low humidity, with an average of 4.4. Cloudiness is considerably greater in the winter than in the summer, especially in November, December, and January, when the trend of temperature is downward and a comparatively little amount of moisture is sufficient for saturation. The least cloudiness occurs in the warm months of July and August, when the moisture capacity of the air is greatest, and the changes in temperature from day to day are relatively slight. The greatest cloudiness in a single month occurred in January, 1911, 7.9, a month of precipitation below the normal; while the least, 1.9, occurred in July, 1894, the month of lowest humidity, when there were only 2 days with appreciable precipitation. There is ordinarily a direct relation between cloudiness and humidity (relative), and between cloudiness and frequency of precipitation, but the relations are not strongly indicated in the average values. Then, too, clouds form and dissolve in strata of atmosphere entirely different from that in which the humidity observations are made; and, further, several types of cloud structure are recognized as accompanying fair-weather conditions. As a result, the relationships mentioned are interrupted to such an extent that it is impracticable from the present data to fix the amount of dependence of the one upon the others.

CLEAR, PARTLY CLOUDY, AND CLOUDY DAYS

The Weather Bureau classes each day as clear, partly cloudy, or cloudy, according to its position in the scale of cloudiness from 0 to 10: viz., clear, 0 to 3; partly cloudy, 4 to 7; cloudy, 8 to 10. Table CXVI contains the number of days of each class for every year since 1873. The averages show an almost even division, with a slight excess in favor of partly cloudy days, 115.6 clear, 135.6 partly cloudy, and 113.9 cloudy days. There is, nevertheless, a great variation in the division from year to year. Ordinarily, the year which has a very small number of clear days is characterized by a considerable excess of cloudy days, but this relation is not always the case. A notable exception was the year 1885, in which occurred only 99 clear days and 93 cloudy days, with the greatest number of the intermediate character on record, 173. In 1895 the greatest number of clear days occurred, 162, while the number of cloudy days, 73, was the least in occurrence in the whole period for any of the three classes. This was the year of least cloudiness, as shown in the previous paragraph. The least number of clear days occurred in

1873, when there were but 86, and in that year there were 132 cloudy days, although there are several years in which the latter number was

TABLE CXVI

ANNUAL NUMBER OF CLEAR, PARTLY CLOUDY, AND CLOUDY DAYS, 1873–1913

(See Fig. 54)

Year	Clear	Partly Cloudy	Cloudy	Year	Clear	Partly Cloudy	Cloudy
1873........	86	147	132	1895.......	162	130	73
1874........	122	142	101	1896.......	136	136	94
1875........	103	143	119	1897.......	137	114	114
1876........	108	126	132	1898.......	153	106	106
1877........	114	143	108	1899.......	127	123	115
1878........	93	158	114	1900.......	120	140	105
1879........	101	163	101	1901.......	154	106	105
1880........	120	147	99	1902.......	120	145	100
1881........	111	141	113	1903.......	117	132	116
1882........	97	159	109	1904.......	94	139	133
1883........	118	147	100	1905.......	101	144	120
1884........	106	153	106	1906.......	102	128	135
1885........	99	173	93	1907.......	93	130	142
1886........	119	155	91	1908.......	133	116	117
1887........	115	135	115	1909.......	89	121	155
1888........	110	128	128	1910.......	129	121	115
1889........	104	128	133	1911*......	114	114	137
1890........	111	133	121	1912*......	133	119	114
1891........	119	122	124	1913*......	132	97	136
1892........	97	136	133				
1893........	130	124	111	Means.....	115.6	135.6	113.9
1894........	144	121	110				

* Not included in means.

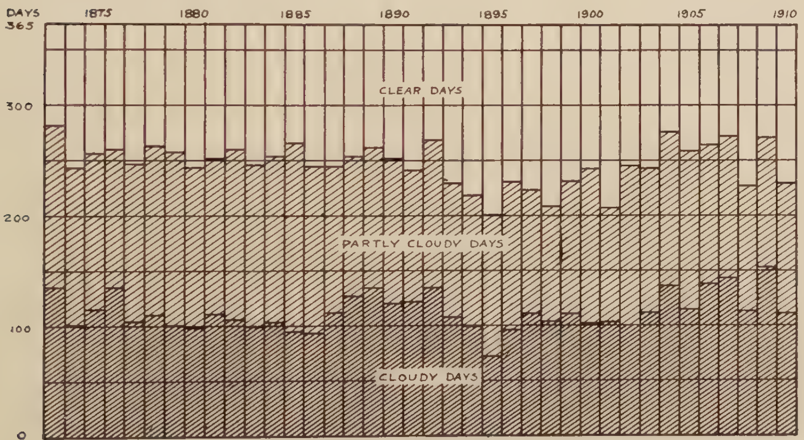


FIG. 54.—Relative frequency of clear, partly cloudy, and cloudy days.

Fig. 54 shows the relative number and frequency of clear, partly cloudy, and cloudy days each year from 1873 to 1910. The actual number of these days may be found in Table CXVI.

exceeded. The greatest number of cloudy days occurred in 1909, there being 155, and the year as a whole had the highest average

cloudiness. The years 1873 and 1905 had precipitation slightly above normal, and 1895 nearly normal. The division of clear, partly cloudy, and cloudy days for the official period is graphically illustrated in Fig. 54.

TABLE CXVII

AVERAGE MONTHLY AND ANNUAL NUMBER OF CLEAR, PARTLY CLOUDY, AND CLOUDY DAYS, 1873–1910

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Clear days	7.7	7.9	7.8	9.2	10.4	9.3	12.8	12.7	11.9	11.1	7.7	7.3	115.6
Partly cloudy days	10.3	9.6	11.3	11.2	12.4	13.9	13.7	13.1	10.7	10.4	9.5	9.5	135.6
Cloudy days	13.1	10.7	11.9	9.6	8.2	6.8	4.5	5.2	7.4	9.5	12.8	14.2	113.9

The average number of such days in each month is shown in Table CXVII. The average values only are given, as too much space would be required for the data in detail, which are of only minor importance. The greatest number of clear days occurs in summer, while the greatest number of cloudy days prevails in

TABLE CXVIII

SUNRISE AND SUNSET, LENGTH OF TWILIGHT, POSSIBLE HOURS OF SUNSHINE, AND EQUATION OF TIME, CHICAGO, ILL., 90TH MERIDIAN TIME

	Sunrise	Sunset	Length of Twilight		Possible Hours of Sunshine	Equation of Time (Approximate)			
						Add to Apparent Time		Subtract from Apparent Time	
			Hours	Minutes		Minutes	Seconds	Minutes	Seconds
January 20	7:18	4:50	1	43.1	9.6	1	22	....	....
February 20	6:39	5:29	1	23.3	10.8	4	31	....	....
March 20	5:53	6:02	1	38.8	12.2	....	....	1	52
April 20	5:02	6:36	1	47.6	13.6	....	....	10	35
May 20	4:25	7:08	2	6.2	14.7	....	....	13	11
June 20	4:14	7:28	2	20.6	15.2	....	....	8	16
July 20	4:32	7:20	2	9.0	14.8	....	....	3	24
August 20	5:03	6:44	1	49.0	13.7	....	....	12	50
September 20	5:35	5:52	1	38.7	12.3	....	....	16	03
October 20	6:08	5:01	1	37.5	10.9	....	....	24	39
November 20	6:46	4:25	1	42.2	9.6	....	....	23	51
December 20	7:14	4:21	1	45.5	9.1	....	....	11	53

Table CXVIII gives the times of sunrise and sunset, length of twilight, and possible hours of sunshine on the 20th of each month; also the equation of time, approximately, Chicago, Ill.

winter. The relatively high frequency of clear days in May is due to the prevailing lake wind during that month, which, with its temperature increasing as it blows over the warmer land, dispels the clouds and reveals the deep azure of the unveiled sky far into the interior (p. 217). A few of the records of the individual months are worthy of note in this connection. The greatest number of clear

days in any one month was 25, in July, 1894, and in this month there were only 2 cloudy days. Not a single cloudy day occurred in July, 1895, July, 1898, or in August, 1896. Except in the second of these, when there were 22 clear days, most of the record is made up of days with intermediate cloudiness. There were 22 cloudy days in November, 1876, December, 1907, and January, 1909, when there were but 2, 6, and 4 clear days, respectively.

TIME OF SUNRISE AND SUNSET, LENGTH OF TWILIGHT, AND EQUATION OF TIME FOR CHICAGO

Table CXVIII gives the time of sunrise and sunset for the 20th day of each month, also the length of twilight on that day, the number of hours of sunshine possible, and the correction which must be applied to mean sun time to give 90th meridian time, the standard

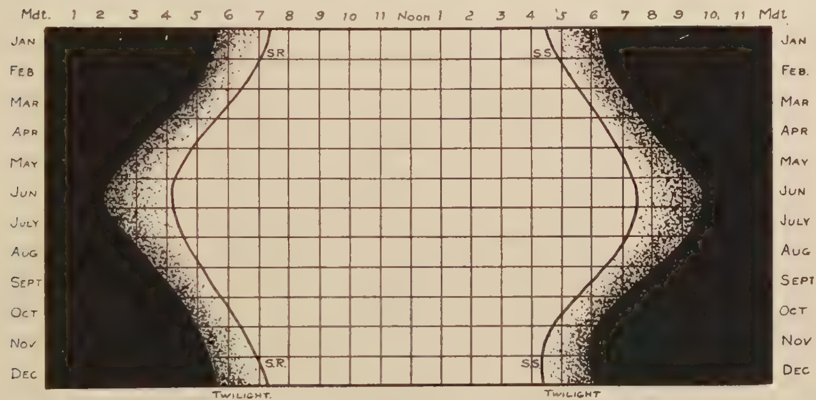


Fig. 55.—Relative duration of daylight, twilight, and darkness.

of time used in Chicago. On July 20, for instance, the sun is in the meridian, and casts a true north shadow, at exactly (12:00:00 − 00:3:24) 11:56:36 a.m. The duration of light, twilight, and darkness, and the relation of each to sunrise and sunset, is shown graphically in Fig. 55.

AVERAGE SUNSHINE, MONTHLY AND ANNUAL

Previous to 1894 no satisfactory instrument was available for recording the duration of sunshine, but at the beginning of that year thermometric recorders were installed and a continuous record

has since been secured. This instrument makes record of the duration of sunshine only, and does not distinguish in any way the differing intensities of the sun's rays. It is adjusted to begin its record whenever the actual disc of the sun is visible, even though clouds intercept a portion of the sunlight, and as a consequence sunshine may be continuous when a thin stratum of cloud covers the entire heavens.

1. *Average duration of sunshine in hours.*—Table CXIX shows the average daily number of hours of sunshine by months and years from 1894 to 1913, inclusive. Ordinarily, we should expect an inverse relation between the average duration of sunshine and the

TABLE CXIX

Average Monthly and Annual Number of Hours of Sunshine, 1894–1913

Year	Jan.	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1894........	5.5	6.1	6.2	8.6	9.0	10.8	12.7	10.1	8.7	4.7	3.7	4.2	7.5
1895........	4.4	7.1	8.2	9.0	10.7	12.5	12.3	10.9	10.7	8.5	4.0	2.5	8.4
1896........	3.3	6.0	7.7	8.4	11.3	12.8	9.9	11.4	7.0	7.0	3.6	2.5	7.6
1897........	3.6	3.3	5.9	6.5	9.0	7.9	8.7	7.5	8.8	8.0	3.1	2.8	6.3
1898........	4.6	4.6	6.8	7.2	8.3	7.6	11.4	8.7	7.3	3.7	4.8	4.7	6.7
1899........	4.7	4.4	3.9	8.7	8.8	10.8	9.7	10.4	6.7	5.7	3.7	3.4	6.8
1900........	3.5	5.0	4.9	8.1	8.2	9.6	8.9	8.3	7.2	7.3	3.9	3.5	6.5
1901........	3.8	7.1	4.3	9.0	7.3	10.4	11.4	7.8	8.3	7.6	5.1	3.7	7.1
1902........	4.2	6.2	6.7	8.9	9.5	8.8	8.8	9.3	6.0	7.4	4.0	3.0	6.9
1903........	4.3	5.9	6.2	8.0	9.9	11.4	11.7	9.4	8.4	7.8	5.5	4.3	7.7
1904........	4.1	5.1	5.3	8.1	9.5	11.1	10.3	10.3	7.0	6.5	6.1	3.1	7.2
1905........	3.6	5.6	6.9	8.8	9.7	11.5	10.3	9.2	7.8	6.8	5.6	4.9	7.6
1906........	3.4	6.1	4.9	9.3	10.8	10.9	11.1	9.0	8.4	4.9	3.8	2.7	7.1
1907........	3.0	6.1	6.3	5.7	8.0	9.3	9.2	9.3	6.6	6.5	6.0	2.7	6.6
1908........	5.4	4.0	5.7	8.1	7.3	12.0	11.5	11.4	10.6	7.7	5.8	4.0	7.8
1909........	3.2	3.2	4.8	6.1	9.9	8.3	10.1	10.0	8.5	6.6	4.6	4.2	6.6
1910........	3.3	5.5	10.0	7.5	8.1	12.2	11.6	9.4	7.4	7.9	4.4	3.9	7.6
1911*.......	2.6	4.6	7.5	7.5	11.6	12.0	11.2	10.5	7.1	5.2	4.1	3.9	7.3
1912*.......	4.0	4.8	6.6	8.7	10.0	12.1	9.7	7.9	7.5	7.9	6.2	4.7	7.5
1913*.......	4.0	7.0	7.1	9.2	9.4	12.4	11.2	9.2	8.1	6.0	4.2	3.7	7.6
Average.....	4.0	5.4	6.2	8.0	9.1	10.5	10.5	9.6	8.4	7.1	4.8	3.8	7.2

* Not included in averages.

average amount of cloudiness, and in the main this relation exists. For instance, in January, 1911, the average cloudiness was 7.9 (Table CXV), considerably above the mean for that month of the year, and the average duration of sunshine was but 2.6 hours for each day, the lowest value for January on record. In September, 1908, the average cloudiness was 2.8, while the average duration of sunshine was 10.6 hours, the former being nearly as much below the mean as the latter was above. Yet this inverse relation is not always in force. A few dense clouds may obscure the sun for long periods, whereas an extensive layer of thin cloud may cause no interruption of sunshine. In winter the same amount and kind of

cloud may veil the sun for a much longer period of time than would be the case in summer, because his rays come to us at a much greater inclination from the vertical. Broken clouds before the sun, when near the horizon, for the same reason interrupt sunshine to a greater extent than would the same clouds in the meridian at noon. The greatest duration of sunshine is, of course, in the summer months, when the days are longest. Only about 9 hours of sunshine are possible on a December day, while in June there may be over 15 hours of sunlight (Table CXVIII). Because of this variation in the length of the day, comparison of the length of sunshine in hours throughout the months of the year is not practicable, more than to call attention to the average duration of sunshine on a day in early summer, 10.5 hours, as compared with one in early winter, 3.8 hours. No month has ever reached its possible duration of sunshine, and none has ever fallen to half its average duration. The month of June, 1896, was marked by the greatest number of hours of sunshine, averaging 12.8 hours for each day. December, 1895 and 1896, averaged only 2.5 hours of sunshine for each day, the former being a month of unusual wetness, while the latter was the driest December on record.

2. *Percentage of possible duration.*—The average percentage of possible sunshine affords a good basis of comparison from month to month and from year to year, and such data are presented in Table CXX. From this it will be seen that the greatest proportional amount of sunshine is received in July, 71 per cent of the amount possible, and that there is a gradual decrease thereafter through October, the decline becoming sharp in November and reaching the minimum for the year in December, 41 per cent. After December the monthly averages increase to the maximum of the following summer. From June to September, inclusive, the record shows more than 80 per cent of sunshine in several instances, that of 86 per cent in the dry September of 1895 being the absolute maximum, although, of course, the actual number of hours during which the sun shone was less than in many cases in the summer months, as the September day is about three hours shorter than the June day. The most remarkable record in the table, however, is that of March, 1910, with 84 per cent of the sunshine possible. No other March has received more than 68 per cent, and in only three other instances has the average reached 58 per cent. This was the warmest, driest, and sunniest March since the official records began. On only one

day did the temperature fall below the normal, and precipitation in appreciable amounts occurred on only three days. The sun shone continuously from sunrise to sunset on ten days, and on seven others the amount was 90 per cent or over. From November to February, inclusive, no record has reached 70 per cent, while in December none has exceeded 53 per cent. As low as 28 per cent of the possible

TABLE CXX

MONTHLY AND ANNUAL PERCENTAGE OF POSSIBLE SUNSHINE, 1894–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1894........	57	57	52	64	67	71	85	73	70	43	37	45	60
1895........	46	67	68	68	73	83	82	79	86	77	41	28	66
1896........	35	55	65	63	78	84	66	82	56	63	36	28	59
1897........	38	31	50	49	62	52	59	54	71	72	32	30	52
1898........	48	44	57	54	57	50	76	63	58	34	49	51	55
1899........	49	42	32	65	61	71	66	75	54	51	38	37	53
1900........	37	47	41	61	56	63	60	60	57	66	40	38	52
1901........	40	67	36	67	50	69	77	56	67	69	52	40	58
1902........	61	58	56	67	65	58	59	67	48	67	41	33	57
1903........	45	55	52	60	68	75	79	68	68	70	56	47	62
1904........	43	47	44	61	65	73	69	74	56	59	62	33	57
1905........	38	53	58	66	67	76	69	66	63	62	57	53	61
1906........	35	58	41	70	74	72	75	65	68	45	39	30	56
1907........	32	58	53	43	55	61	62	67	53	59	61	29	53
1908........	56	36	48	61	50	79	77	82	85	70	59	43	62
1909........	33	30	40	46	68	55	68	72	68	60	47	46	53
1910........	34	52	84	56	55	80	78	68	60	71	45	42	60
1911*.......	28	44	63	56	79	79	75	76	57	47	41	42	57
1912*.......	42	46	55	65	69	80	65	57	67	71	63	51	61
1913*.......	42	66	60	69	64	82	75	67	65	54	43	41	61
Average.....	43	50	52	60	63	69	71	69	68	64	49	41	58

* Not included in average.

HIGHEST AND LOWEST MONTHLY ANNUAL PERCENTAGES, 1894–1911

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Highest mean	61	67	84	70	79	84	85	82	86	77	62	53	66
Lowest mean	28	30	32	43	50	50	59	54	48	34	32	28	52
Range	33	37	52	27	29	34	26	28	38	43	30	25	14

amount of sunshine has been experienced twice in the period of record, both instances being in December, in 1895 and 1896, respectively (p. 259). The reasons for the low percentages of sunshine in November, December, and January—less than 50 per cent in each month—are to be found in the same conditions which produce excess of cloudiness at that time of the year (p. 254).

HOURLY SUNSHINE CONDITIONS

1. *Average hourly percentage of sunshine, by months.*—Table CXXI shows the average hourly duration of sunshine, by months, from 1894 to 1910, inclusive, and the same data are graphically portrayed in

TABLE CXXI

AVERAGE HOURLY DURATION OF SUNSHINE, 1894–1910

	4–5 A.M.	5–6 A.M.	6–7 A.M.	7–8 A.M.	8–9 A.M.	9–10 A.M.	10–11 A.M.	11–Noon	Noon–1 P.M.	1–2 P.M.	2–3 P.M.	3–4 P.M.	4–5 P.M.	5–6 P.M.	6–7 P.M.	7–8 P.M.	Mean Daily No. of Hours of Sunshine	Mean Daily Possible No.	Percentage of Possible No.
January	...	...	...	25	31	40	48	54	54	52	45	37	34	31	...	...	4.0	9.5	43
February	...	...	31	33	41	50	58	64	64	61	55	47	39	34	...	...	5.4	10.6	50
March	...	38	36	41	49	56	60	63	65	63	57	50	42	34	33	...	6.2	12.0	52
April	20	45	48	54	61	66	71	72	72	72	69	62	53	44	38	...	8.0	13.7	60
May	44	47	52	60	67	74	76	76	78	76	72	66	58	46	40	32	9.1	14.6	63
June	47	51	59	68	75	81	83	83	83	81	78	74	68	55	49	43	10.5	15.2	69
July	48	50	58	68	76	80	83	83	82	83	81	77	71	63	55	51	10.5	14.9	71
August	50	48	54	61	70	76	80	84	84	82	80	75	67	53	48	44	9.5	13.8	69
September	...	47	48	55	63	71	73	73	74	73	71	66	56	51	45	...	8.4	12.5	68
October	...	22	44	50	59	66	71	72	71	69	64	56	49	52	...	...	7.1	11.1	64
November	...	...	27	30	39	49	56	57	57	54	48	39	36	...	...	...	4.8	9.8	49
December	...	...	...	25	28	37	43	48	49	45	38	31	30	...	...	...	3.8	9.2	41
Annual	17	29	38	47	55	62	67	69	69	68	63	57	50	39	26	18	7.2	12.4	58

Table CXXI shows the average hourly duration of sunshine, expressed in percentage of the possible amount, from 1894 to 1910. These values are graphically portrayed in Fig. 56.

Fig. 56. The period of most sunshine is limited to a few hours before and after noon in the months of June, July, and August, when the average is 80 per cent or more of the amount possible, and the least sunshine is received just after sunrise in the winter months. On the average, for the year as a whole, the greatest amount of sunshine, 69 per cent, occurs from 11 A.M. to 1 P.M.

2. *Sunshine phases.*—The chief phases of sunshine phenomena are shown in Table CXXII. The time of occurrence of the mean percentage of sunshine for the month varies from season to season, somewhat after the manner of the mean temperature (p. 136), while the equated time of maximum sunshine condition is 12:30 P.M. In summer the first mean occurs earlier than the average, 9:22 A.M., and the second later than the average, 3:58 P.M. In winter the occurrence is reversed, the first mean occurring later and the second earlier than the average. The mean percentage is shown in the column of the first mean, and its value in hours of sunshine in the column of the second mean. The figures in this table, of course, harmonize with those in Table CXXI, except that they show exact times.

NUMBER OF DAYS WITH ONE HOUR OR MORE OF SUNSHINE, ANNUAL AND MONTHLY

During the summer season a day with less than 1 hour of sunshine seldom occurs, and even in the winter months, when the mean duration of sunshine is less than 50 per cent of the amount possible, the number of days with 1 hour or more of sunshine averages somewhat more than 3 in every 5 days. These facts are brought out by Table CXXII*a*, which gives the number of such days for each month and year from 1894 to 1913, inclusive. The average numbers for June and July each come within 1 of the number of days in the month; and in 14 of the 20 years' record of the former the sun shone on every day for at least 1 hour. This is also true in 10 years for the month of July, and in 7 years for the month of August. There are a few occasions of the kind in March, April, May, and September, but none from October to February, inclusive, although some of the monthly records are quite high as compared with the average values. There are several reasons for the greater frequency in the summer months of days of 1 hour or more of sunshine. The interval between sunrise and sunset is considerably longer in that season (p. 263); because of temperature conditions and of storm

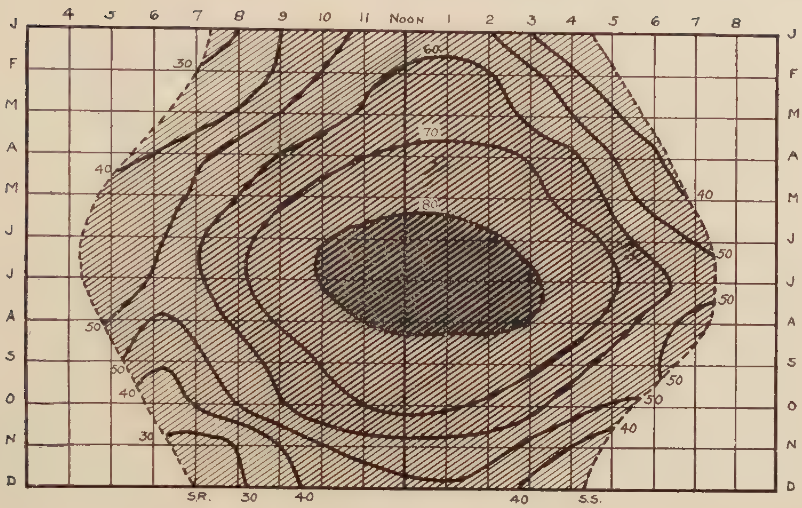


FIG. 56.—Mean hourly sunshine.

Fig. 56 shows the mean hourly percentage of sunshine, expressed in terms of the possible amount, for each hour of the day and each month of the year, based upon records from 1894 to 1910. The dotted lines marked *S.R.* and *S.S.* indicate the time of sunrise and sunset, respectively (see Table CXXI).

TABLE CXXII

SUNSHINE PHASES

(90th Meridian Time)

	Sunrise 15th	First Mean		Maximum		Second Mean		Sunset 15th
		Time Hours Ending A.M.	Value in Percentage	Time Hours Ending P.M.	Value in Percentage	Time Hours Ending P.M.	Value in Hours	
January	7:16	10:20	43	12:00	54	3:30	4.0	4:44
February	6:46	10:00	50	12:30	64	3:50	5.4	5:23
March	6:02	9:20	52	1:00	65	4:20	6.2	5:56
April	5:09	8:50	60	12:50	72	4:20	8.0	6:31
May	4:29	8:30	63	1:00	78	4:10	9.1	7:03
June	4:14	8:10	69	12:00	83	4:50	10.5	7:27
July	4:28	8:20	71	11.40	83	5:00	10.5	7:24
August	4:58	8:50	69	12:40	84	4:50	9.5	6:51
September	5:30	9:30	68	1:00	74	4:20	8.4	6:00
October	6:03	9:40	64	12:10	72	3:00	7.1	5:09
November	6:40	10:00	49	12:20	57	2:50	4.8	4:29
December	7:11	10:50	41	12:50	49	2:40	3.8	4:20
Year	5:44	9:22	58	12:30	69	3:58	7.2	5:56

Table CXXII shows the sunshine phases. The first and last columns give the time of sunrise and sunset for the 15th of each month, the second and sixth columns show the time during the morning and afternoon when the average daily percentage of sunshine occurs, and the third column shows this amount, while the seventh column shows this value expressed in hours. The two columns under "Maximum" show the time at which the greatest amount of sunshine occurs and the value expressed in percentage of the possible amount. These figures are based upon records from 1894 to 1910.

movement, cloudiness is on the average greater in winter than in summer (p. 254); and while the total precipitation is much heavier in the latter season, the frequency of days with precipitation is decidedly less (p. 167), and periods of rainfall are relatively brief.

TABLE CXXII*a*

NUMBER OF DAYS EACH MONTH AND YEAR WITH ONE HOUR OR MORE OF SUNSHINE, 1894–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1894........	23	19	26	28	29	30	31	31	30	21	16	22	306
1895........	19	25	27	27	30	30	31	30	30	29	17	16	311
1896........	20	25	30	28	31	30	28	31	25	27	19	16	310
1897........	18	15	21	24	29	27	30	30	29	28	16	18	285
1898........	21	19	24	23	28	30	31	28	27	18	23	22	294
1899........	24	21	18	30	28	30	30	30	25	25	19	21	301
1900........	16	21	22	25	29	28	28	27	26	26	20	20	288
1901........	19	25	18	26	26	30	31	30	28	29	22	17	301
1902........	26	22	23	27	30	29	28	31	20	28	20	14	298
1903........	20	21	22	24	29	30	30	29	29	30	25	23	312
1904........	22	24	26	28	30	30	31	30	28	28	26	15	318
1905........	19	23	27	27	29	30	30	27	28	27	24	23	314
1906........	16	23	22	28	30	29	31	30	27	23	20	16	295
1907........	17	26	26	19	26	28	30	29	25	27	24	16	293
1908........	23	16	25	28	24	30	31	31	30	27	25	19	309
1909........	18	15	20	24	30	27	30	31	27	26	24	18	290
1910........	18	24	31	24	27	30	31	31	24	29	21	19	309
1911........	13	18	28	26	30	30	29	31	28	25	22	20	300
1912........	24	21	28	28	29	30	31	29	27	28	27	23	325
1913*.......	23	25	27	26	26	30	31	28	27	24	16	19	302
Mean.......	19.8	21.2	24.4	26.0	28.6	29.4	30.1	29.8	27.0	26.4	21.6	18.8	303.1

* Not included in means.

As a result, therefore, of the longer days, and of the conditions of temperature, cloudiness, and precipitation, the summer months are far more favorable for the occurrence of sunshine than are those of the cold period.

LONGEST PERIODS OF SUNSHINE

It occasionally happens that periods of settled weather with continuous sunshine from sunrise to sunset extend over several days' time. Table CXXIII designates all such periods of 4 or more consecutive days from 1894 to 1913, inclusive. It is apparent that these periods are more frequent in the early autumn than at any other time, although a number have occurred in the early spring. They happen seldom in the summer because of the active convection currents of warm afternoons, which usually give rise to clouds of the cumulous type and so interrupt at intervals the rays of the sun. They are also very infrequent in winter, because of the favorable conditions for cloud formation then prevailing (p. 254). The longest periods of continuous sunshine, 8 and 7 days in extent, occurred in the

autumn, the first from September 27 to October 4, 1897, and the second from September 5 to 11, 1908. In 1901, the year of least precipitation in the official records, and one of repeated drouths, there were six periods of four or more days of continuous sunshine, while 1906 and 1911 were marked by three each.

LONGEST PERIODS WITHOUT SUNSHINE

In the winter season several days may occur in succession with skies so heavily clouded that no sunshine is recorded. These periods, wherever they have covered 4 or more consecutive days, are indicated in Table CXXIV. The longest period on record is one of

TABLE CXXIII

PERIODS OF FOUR OR MORE CONSECUTIVE DAYS WITH 100 PER CENT OF SUNSHINE, AUGUST, 1893, TO DECEMBER, 1913

Year	From	To	No. Days
1894	September 25	September 28	4
1895	October 16	October 19	4
1897	September 27	October 4	8
1899	August 16	August 19	4
1901	April 25	April 29	5
	July 19	July 23	5
	September 3	September 6	4
	September 21	September 24	4
	October 19	October 23	5
	October 27	October 30	4
1903	January 15	January 18	4
1904	October 29	November 1	4
1905	October 3	October 8	6
1906	May 19	May 22	4
	June 9	June 12	4
	September 15	September 18	4
1908	September 5	September 11	7
1911	April 22	April 25	4
	May 4	May 7	4
	June 30	July 4	5
1913	April 14	April 19	6
	April 29	May 2	4
	June 8	June 14	7

10 days, from December 16 to 25, 1895. Another of 9 days occurred from February 4 to 12, 1897. No periods of the kind have ever occurred in the summer months, but one of 4 days was recorded in September, 1902, and one of 5 days in May, 1908. Otherwise, their occurrence has been confined to the months from November to February, inclusive.

COMPARISON OF AVERAGE PERCENTAGE OF SUNSHINE AT CHICAGO WITH THAT OF OTHER PORTIONS OF THE UNITED STATES

Table CXXV gives the percentages of sunshine by months and years for the same cities of the United States as were used in the comparisons of humidity and precipitation (pp. 247, 165), and the

values are illustrated in Fig. 57. In making comparisons, however, it should be borne in mind that the length of day, as well as the

TABLE CXXIV

PERIODS OF FOUR OR MORE CONSECUTIVE DAYS WITHOUT SUNSHINE, AUGUST, 1893, TO DECEMBER, 1913

February, 1894	8th to 14th inclusive,	7 days
November, 1895	6th " 9th "	4 "
December, 1895	16th " 25th "	10 "
January, 1896	23d " 26th "	4 "
November, 1896	17th " 21st "	5 "
January, 1897	13th " 17th "	5 "
February, 1897	4th " 12th "	9 "
December, 1898	19th " 22d "	4 "
December, 1899	9th " 13th "	5 "
January, 1900	9th " 13th "	5 "
January, 1900	16th " 19th "	4 "
January, 1901	7th " 11th "	5 "
November, 1901	22d " 25th "	4 "
September, 1902	23d " 26th "	4 "
December, 1902	2d " 6th "	5 "
December, 1904	23d " 27th "	5 "
December, 1905	17th " 22d "	6 "
May, 1908	4th " 8th "	5 "
December, 1909	11th " 16th "	6 "
January, 1911	11th " 14th "	4 "
November, 1913	26th " 30th "	5 "

TABLE CXXV

MONTHLY AND ANNUAL PERCENTAGE OF POSSIBLE SUNSHINE FOR 15 SELECTED CITIES FOR A VARYING NUMBER OF YEARS

(See Fig. 57)

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Portland, Ore.	26	30	39	48	47	54	71	65	53	44	25	23	44
San Francisco, Cal.	48	53	57	67	66	72	69	61	68	69	57	54	64
Yuma, Ariz.	77	83	87	95	96	99	90	90	92	90	87	81	89
Havre, Mont.	53	55	67	70	62	70	80	73	64	60	44	45	62
Denver, Colo.	68	68	66	66	59	68	69	68	73	75	68	66	68
El Paso, Tex.	73	78	82	88	90	93	74	74	86	86	73	71	81
St. Paul, Minn.	49	58	52	61	56	60	70	64	60	53	46	44	56
Omaha, Neb.	55	59	54	60	59	65	72	69	66	62	56	50	61
Galveston, Tex.	53	49	55	61	68	76	71	68	70	74	60	54	63
Marquette, Mich.	38	43	52	51	50	61	61	56	48	37	24	23	45
Chicago, Ill.	43	50	52	60	63	69	71	69	68	64	49	41	58
New Orleans, La.	50	49	57	61	65	63	52	53	61	63	55	46	56
Northfield, Vt.	42	48	42	49	51	57	58	60	50	45	32	33	48
New York, N.Y.	51	60	56	60	58	61	62	60	61	58	53	51	58
Jacksonville, Fla.	52	55	68	72	72	68	63	64	58	57	61	53	62

The data in the above table are for the total period of record for each station shown, up to and including 1910. The periods differ in length, however, as the instruments were not all installed at the same time.

percentage of sunshine, is an important factor; and that the length varies more and more from summer to winter as latitude increases.

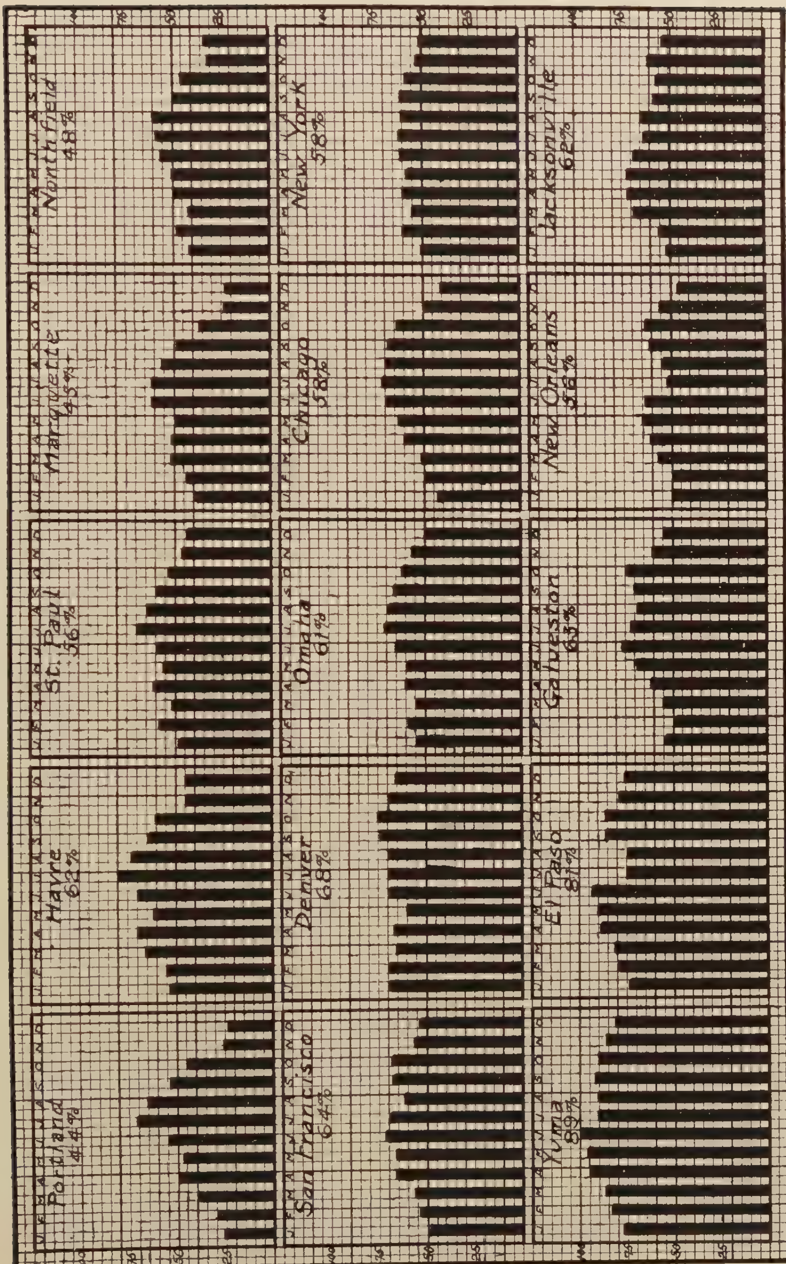


FIG. 57.—Average monthly and annual percentages of possible sunshine.

The greatest proportion of possible sunshine occurs in the arid regions of the Southwest, represented in the table and graph by Yuma, Ariz., and El Paso, Tex., while the elevated plateaus of the Rockies, and the Plains states to the east, have also comparatively high percentages. The regions of least sunshine are those of the northeastern sections, near which most of our storm areas pass in their egress into the Atlantic. There is no uniformity in the amount of possible sunshine by months in the section of the country east of the Rockies, but, as a rule, it is greatest in summer time, and this is always the case in Chicago, as stated above. In the Pacific coast region, moreover, the season of protracted sunshine corresponds to the dry season there, while a falling off occurs in the colder months of the year.

OCCURRENCE OF DENSE FOG

In the usage of the Weather Bureau fog is designated dense when objects at a distance of 1,000 feet or less are entirely obscured. Relative humidity in a dense fog is usually 100 per cent, but occasionally in the midst of large cities oily vapors discharged from innumerable chimneys condense upon the fog particles and prevent evaporation, even when the humidity of the air is considerably below the saturation point. Possible instances of this kind occurred on September 10, 1888, and on October 18, 1889, when the records show dense fog with relative humidities of 52 and 58 per cent, respectively. Fogs in Chicago are sometimes blown in from the lake, but in winter they are usually caused by warm air coming in contact with snow-covered ground, or after a severe cold spell by moist lake winds blowing over the colder surfaces of the ground, whether snow-covered or bare. Ordinarily, fog is not to be taken as an indication of the approach of precipitation, but rather the reverse. This is especially true during the summer months, when fog occurs early in the morning, or in low places at night, but is rapidly dispelled after sunrise by the increasing heat of the day.

Prior to 1895 the same distinction as is made today between light and dense fog was not taken into account, so that a complete record of the occurrence of dense fog is limited to the period 1895 to 1913, inclusive, and the data are shown in Table CXXVI. The years 1900, 1903, 1904, and 1911 were marked by a comparative frequency of dense fogs, there being 26, 25, 20, and 20, respectively, while the average occurrence for the year is 13.7. The year 1908 was freest from such phenomena, with only 6 occurrences. In the individual months,

March is the time of greatest frequency, and July that of least, there having been but three dense fogs in the latter month within the period of record. In March, 1903, dense fog occurred on 10 days, and four of these were consecutive. The average number for the year, or for any month of the year, is not large, and it is only seldom that the

TABLE CXXVI

NUMBER OF DAYS EACH MONTH AND YEAR WITH DENSE FOG FOR ONE HOUR OR LONGER, 1895–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895........	2	1	......	1	......	......	......	1	......	......	5	4	14
1896........	5	2	1	......	......	2	......	......	4	......	......	3	17
1897........	1	2	4	......	......	......	......	......	......	2	3	2	14
1898........	5	2	2	1	......	......	......	......	1	2	1	2	16
1899........	......	......	2	......	1	......	......	......	......	4	4	3	14
1900........	6	2	......	6	2	3	......	......	......	4	3	......	26
1901........	1	......	1	2	4	......	......	1	......	1	2	......	12
1902........	......	1	3	......	......	......	......	......	1	......	1	2	8
1903........	3	3	10	1	4	......	......	......	1	1	2	......	25
1904........	2	1	4	2	2	1	1	......	3	......	2	2	20
1905........	1	1	......	4	......	2	......	......	......	......	......	......	8
1906........	1	1	2	......	......	......	......	......	......	......	1	3	8
1907........	1	2	1	1	......	......	......	2	......	......	1	2	10
1908........	......	......	1	1	2	......	......	......	1	1	......	......	6
1909........	......	2	......	1	......	3	......	......	1	2	1	3	13
1910........	3	......	1	......	1	......	......	1	2	......	......	......	8
1911*.......	3	3	......	4	......	......	1	......	2	3	......	4	20
1912*.......	4	1	2	......	......	......	1	......	......	......	......	1	9
1913*.......	1	......	1	1	......	......	......	......	2	4	4	1	14
Totals, 1895–1913......	39	24	35	25	16	11	3	5	18	24	30	32	262
Average.....	1.9	1.2	2.0	1.2	1.0	0.7	0	0.3	0.9	1.1	1.6	1.6	13.7

* Not included in means.

conditions of fog are such as to interfere materially with transportation. Occasionally dense fogs at night are, by the greater heat of the day, rendered less dense, but become dense again the following night; although it is not often in Chicago that fogs of either kind continue through the entire twenty-four hours.

DARK DAYS

Sometimes in the morning of a week day, and usually in cold weather, a combination of heavy clouds, fog, and smoke hangs in a pall over the city, and the condition occasionally extends over a period of several hours. On these "dark days" objects can be seen on the street only with great difficulty, if at all, unless artificial light is used, and at such times it is commonly found necessary to use the street-lighting system the same as if it were night. The intensity of these conditions in Chicago, however, is never as aggravated as that of the famous London fogs which occasionally bring all traffic to a standstill.

TABLE CXXVII

DARK DAYS, 1902 TO 1913

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1902												10th* All day	1
1903											28th 12:00 M. to 12:20 P.M.		1
1904	6th 7:15 A.M. to 9:30 A.M. 12th† 8:00 A.M. to 9:00 A.M.			9th 1:00 P.M. until during afternoon			27th‡ Afternoon					13th† 7:30 A.M. to 9:00 A.M. 14th† 1st half of forenoon	6
1905	6th 11:00 A.M. to 12:00 M. 23d 7:00 A.M. to 9:00 A.M.	4th Forenoon								18th 8:40 A.M. to 9:00 A.M.	13th* 3:00 P.M. to 4:30 P.M.	17th* All day 18th* Afternoon 19th All day 28th* Afternoon	9
1906	21st 1:00 P.M. to 1:30 P.M.	5th 10:30 A.M. to 11:30 A.M. 6th 10:30 A.M. to 1:30 P.M. 13th 1:00 P.M. to 3:00 P.M. 23d Late afternoon	2d* All day 7th† 10:00 A.M. to 11:30 A.M.									11th Forenoon 13th 4:00 P.M. to 4:19 P.M. 18th† 7:00 A.M. to 10:00 A.M. 20th 7:00 A.M. to 9:00 A.M. 24th 7.00 A.M. to 9.00 A.M. and 3:30 P.M. to 4:30 P.M.	12

1907........	29th† 3:30 P.M. to 5:00 P.M.		26th† 3:30 P.M. to 3:37 P.M.						18th† 8:30 A.M. to 10:00 A.M.			4th 1:30 P.M. to 2:30 P.M. 17th All day	5
1908........	3d 7:00 A.M. to 9:00 A.M.		27th 9:45 A.M. to 10:00 A.M. 3:30 P.M. to 4:00 P.M.										2
1909........						4th* 8:15 A.M. to 8:45 A.M.		27th* 12.45 P.M. to 1.15 P.M.					2
1910........				16th*† 1:05 P.M. to 1:10 P.M. 22d† 4:00 P.M. to 4:20 P.M.					12th 7:00 A.M. to 7:30 A.M.				3
1911........	11th 8:30 A.M. to 9:15 A.M.		29th 9:45 A.M. to 11:00 A.M.									15th† 7:00 A.M. to 10:17 A.M.	3
1912........	26th† All afternoon												1
1913........		16th 7:20 A.M. to 11:00 A.M.	7th 6:55 A.M. to 8:30 A.M.						29th† 6:40 A.M. to 11:15 A.M. 30th† 12:35 P.M. to 12:45 P.M.		26th† 9:25 A.M. to After sunset	24th† Before sunrise to 12:40 P.M. 31st Before sunrise to 2:30 P.M.	7
Total number	9	6	6	3	0	1	1	1	4	1	3	17	52

* Heavy clouds. † Extreme darkness. ‡ Brisk S.E. to S.W. winds.

Table CXXVII contains a list of dark days from 1902 to 1913 on which darkness prevailed to such an extent that the day became as dark as night. This is usually caused by a combination of dense clouds, fog, and smoke.

Such conditions occur in Chicago only when the wind is so light as not to carry the smoke away, and the sooty particles become coated with moisture from the fog and settle to the strata near the surface, while the heavy clouds above prevent immediate dissipation by the heat of the sun. It is seldom that the condition continues past the middle of the day, as by that time the wind usually reaches a velocity sufficient to relieve the situation. Table CXXVII gives a list of such "dark days" from 1902 to 1913, inclusive. Prior to that period such days were classed as days with fog, so that they are not readily distinguishable in the records. During the 12 years beginning with 1902 there have been 52 days which come under the classification of "dark days," as given above, 17 occurring in December, 9 in January, 6 each in February and March, while the other months with the exception of May have had from 1 to 4 each. Of the total number, 15 were marked by the intense darkness of night, and these are indicated in the table by the dagger (†). Sometimes a considerable degree of darkness is caused by clouds alone during or just previous to a severe thunderstorm in summer, and either fog or smoke may bring about a medium darkness, but the dates in the table are those upon which the condition was most pronounced, and are due to the combination of factors described in the first part of the paragraph.

EFFECT OF CLOUDS AND SUNSHINE UPON TEMPERATURE AND HUMIDITY

Following the discussion of the conditions of cloudiness and sunshine, it will be interesting to note their effect upon temperature and relative humidity. For this purpose a period of 3 days has been selected upon which the cloudiness and sunshine varied considerably, and when no lake wind prevailed to increase the moisture content of the air, and only the ordinary diurnal changes in velocity occurred, May 17, 18, 19, 1910, and the relations are shown in Fig. 58. The condition of weather is indicated at the bottom of the graph, solid black strips representing cloudy, shaded strips partly cloudy, and open strips clear conditions, respectively.

During May 17, when the weather was cloudy, there was not much variation in temperature, except in that portion of the afternoon in which the clouds broke away temporarily, and the range for the day was but 8°. On the following day the temperature rose rapidly under continuous sunshine, the range being 28°, while on the last day of the period the diurnal change, although pronounced, was

not so great as on the day previous, because more or less cloudiness prevailed. The range on this day was 20°. It will thus be seen how, other influencing factors being fairly constant, the temperature

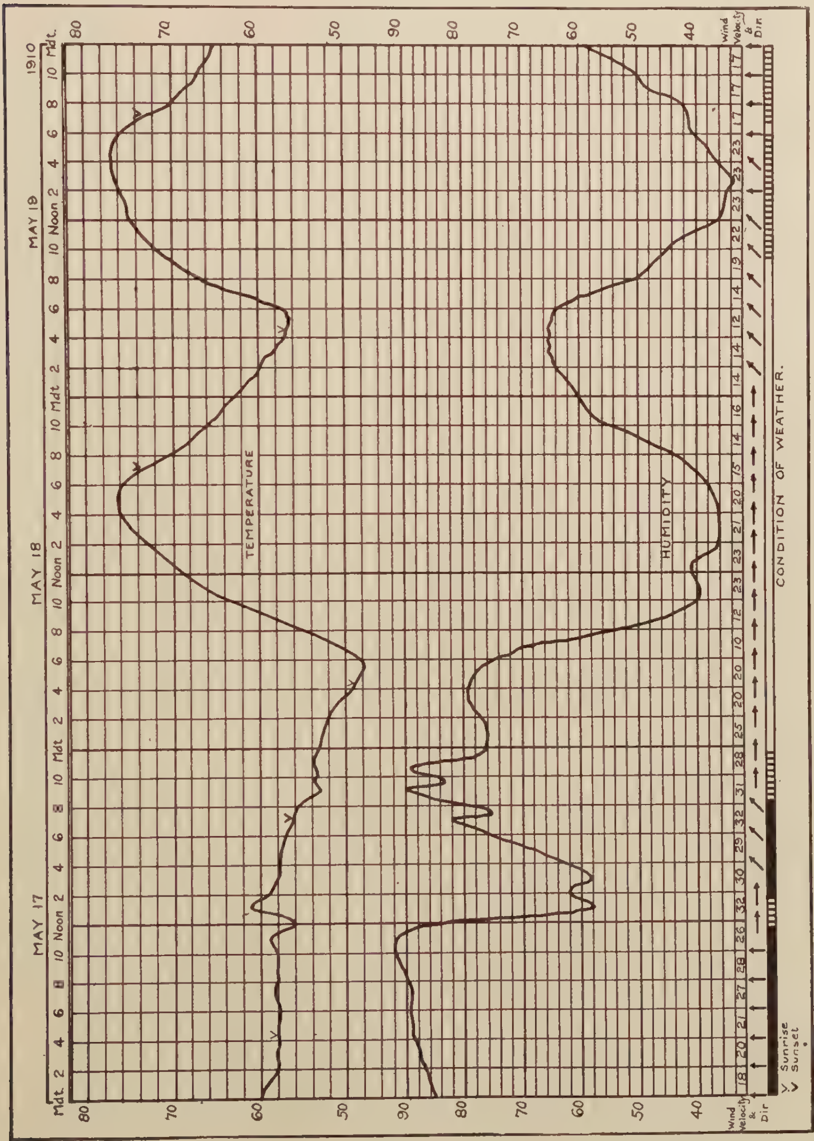


FIG. 58.—Effect of clouds and sunshine on temperature and humidity.

responds to the action of clouds and sunshine. There is comparatively little range during cloudy weather in either day or night, but in clear weather relatively low minimums are experienced at night, and relatively high maximums in the day. The effect of clouds and sunshine upon relative humidity is also quite plain, the curves taking the opposite direction to those of temperature, with fully as close response to the variation of condition. The changes in relative humidity in this illustration, however, are rather the results due to changes in temperature which are caused by the varying conditions of cloudiness and sunshine. Had the temperature remained constant throughout the entire time, the changes shown in the relative humidity would not have occurred. There would, nevertheless, have been a slow rise toward total saturation, such as occurred during that portion of the 17th when the temperature remained nearly stationary at 58°. We may, therefore, say that changes in relative humidity, other things being equal, are effected through variations in temperature resulting from the prevailing conditions of cloudiness and sunshine.

PART V

WIND DIRECTION AND VELOCITY

WIND DIRECTION AND VELOCITY

The wind instruments, of course, were moved with every change in the location of the Weather Bureau office. From November 1, 1870, to June 8, 1873, they were exposed successively in three different locations, and since the latter date four changes have been made. The elevation of the anemometer has been raised with each change since 1873 to its present altitude above the surface, 310 feet (p. 370). The elevation of the anemometer in securing records of wind movement and velocity is an important factor, as will be brought out in a later paragraph, and also that of the influence of the surrounding objects. The record of wind direction, however, does not depend in nearly so large a degree upon the character of the exposure of the wind vane, or anemoscope, and the position of that instrument in all locations was excellent. The wind instruments and even the sunshine recorder in order to have good exposures must be placed at elevations considerably above the roofs of the surrounding buildings, while this is not essential in the case of the thermometers and rain and snow gages. For example, at present the anemometer, anemoscope, and sunshine recorder are on top of the dome of the Federal Building, while the thermometers and precipitation gages are placed on the roof of the north wing of the building, 170 feet or more lower down.

The anemometer and its register afford a record of the actual number of miles of wind which pass the instrument, and this record is designated the total wind movement for the hour, day, month, or year, as the case may be. The average hourly velocity of the wind for any day is the total movement of that day divided by 24, the number of hours in the period; the average monthly velocity and the average yearly velocity are obtained in similar manner, but the values are always given in miles an hour. It is obvious that the highest velocity for a day, or for a storm, is seldom maintained through the extent of an hour, and in obtaining this value, called the maximum velocity, the period of five minutes in which the wind blew at its fastest rate is taken as the basis of calculation. All references to maximum velocities in the ensuing pages will be understood, therefore, to be for the 5-minute period of highest rate of movement. At different times during the maintenance of the wind records it was

customary to measure the rate of the fastest mile in each day's wind movement, and to record this value as the extreme velocity. However, the periods of such record are broken, and as a consequence no data on extreme velocities are presented in this bulletin, except for a single reference to the fastest mile so far as known (p. 289).

Only eight possible directions of the wind are considered in Weather Bureau practice; namely, north, northeast, east, southeast, south, southwest, west, and northwest, and no intermediate directions appear in the automatic records. A record of northeast therefore means that the position of the vane at the time was nearer northeast than either north or east. The term "prevailing wind direction" is used to indicate the direction of wind which obtains longer than that of any other quarter. It does not necessarily mean that the prevailing wind blows for a longer time than those from all other directions, and in fact it often happens that the prevailing direction occurs in a relatively small portion of the whole time for which the record is made. For instance, should the wind blow from the northwest for 4 hours of the day, and during the remainder of 20 hours be divided among the other seven points of the compass so that none persist for 4 or more hours, northwest would be considered the prevailing direction for that day. Again, should the wind blow on any day from the northeast for 7 hours, and from the southwest, south, and southeast for 6, 6, and 5 hours respectively, it would be classed as a day having its prevailing direction from the northeast, although, as a matter of fact, the wind blew from some southerly direction for more than two-thirds of the entire day. The illustrations are extreme, of course, but such cases are entirely possible, and some instances will be pointed out later where winds of comparatively short duration are recorded as the prevailing winds for the periods in which they occur. The term "prevailing wind direction" is used with reference to the hour, the day, the month, and the year. The prevailing direction for the day is determined from the prevailing directions of its hourly record; that of the month, from its daily record; and that of the year, from its monthly record. The determination of the prevailing direction for the day, month, and year is therefore based upon the number of occurrences of prevailing directions for the next smaller unit, and not upon the actual length of time occupied by each direction. For example, suppose north and west winds be the prevailing hourly directions for a period of several days, as given in Auxiliary Table K. Calculated, as is the

custom, from the prevailing directions of the three days, the prevailing direction of the period would be recorded as *north;* as a matter of fact, the west wind during the period blew for 41 hours against only 31 hours of north wind, and *west*, therefore, is the true prevailing

AUXILIARY TABLE K

	North	West	Prevailing Direction
First day	13 hours	11 hours	North
Second day	3 hours	21 hours	West
Third day	15 hours	9 hours	North

direction. The occurrence of such differences, however, is very infrequent, but attention is called here to the possibility, and later an interesting case of the kind, extending over a record of several years, will be pointed out (p. 301).

PREVAILING WIND DIRECTION, MONTHLY AND ANNUAL

The prevailing wind direction for the various months and years from 1872 to 1913, inclusive, is shown in Table CXXVIII. For the entire period the prevailing direction is southwest, and this is true by decades also except that of 1891 to 1900, which was northeast. This decade covered a portion of the 15-year period when the Weather Bureau occupied quarters at the Auditorium Tower, and its proximity to the lake may possibly have turned the scale in favor of the northeast wind. This theory seems plausible in view of the fact that northeast winds continued to be the more frequent up to the close of the Auditorium Tower period in June, 1905 (see also p. 301). The lake controls the wind direction during much of the spring and early summer, but throughout the remaining months of the year the movement is chiefly from the southwest, and were it not for lake influence (p. 142), the preponderance from this direction would at all times be decided. During the 42-year period the prevailing direction was southwest for 24 years, northeast for 8 years, north and south for 4 years each, and west for 2 years, while northwest, southeast, and east have never been the prevailing yearly direction. It would ordinarily be expected that the years in which the prevailing direction was north, 1881, 1883, 1884, and 1885, were unusually cold. The first of these was warmer than the average, and while the remaining three were below the yearly normal, none had a deficiency in temperature reaching 2° (Table I). Of these four years, 1883 and

1885 were the most severe, averaging 1.8° and 1.5° below the normal, respectively, but the deficiency was due largely to cold weather of the winter months, when the prevailing wind direction was southwest or west. As a matter of fact, many of the severest cold-wave areas

TABLE CXXVIII

Monthly and Annual Prevailing Direction of Wind, 1872–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1872	SW	NE	NW	SW	W	SW	SW	SW	SW	S	SW	SW	SW
1873	SW	SW	W	N	N	SW	SW	NE	SW	SW	SW	SW	SW
1874	S	SW	SW	NE	NE	SW	SW	NE	SW	SW	S	SW	SW
1875	W	SW	SW	N	SW	N	NE	S	SW	SW	SE	SE	SW
1876	SW	W	W	SW	SW	SW	SW	S	N	S	S	W	SW
1877	S	N	N	N	E	S	SW	SW	SW	NE	SW	SE	SW
1878	S	NE	NE	NE	W	NE	SE	SW	SW	SW	W	SW	SW
1879	W	W	SW	NE	NE	S	S	S	S	S	S	W	S
1880	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	W	W	SW
1881	W	SE	W	SW	N	N	N	N	S	S	S	SW	N
1882	SW	SW	W	NE	NE	SW	SW	NE	NE	S	S	W	SW
1883	SW	W	N	N	N	N	SW	SW	NE	NE	S	SW	N
1884	SW	S	N	N	N	N	E	E	S	SW	W	SW	N
1885	SW	SW	S	N	N	N	N	N	E	N	W	SW	N
1886	W	S	NW	N	N	NE	N	S	S	S	S	S	S
1887	NW	SW	N	SW	NE	SW	SW	E	E	SW	SW	SW	SW
1888	W	W	NE	NE	E	NE	NE	SW	SW	SW	SW	SW	SW
1889	SW	SW	NE	NE	NE	SW	SW	SW	SW	NE	NW	SW	SW
1890	SW	SW	NW	NE	NE	SE	SW	NE	NE	N	SW	SW	SW
1891	SW	SW	NE	NE	NE	NE	SW	SW	SW	SW	SW	SW	SW
1892	NW	NE	NE	NE	NE	NE	NE	NE	SW	SW	NW	SW	NE
1893	NW	W	NE	NE	NE	NE	NE	NE	SE	S	SW	SW	NE
1894	SW	SW	SW	NE	NE	SW	NE	NE	S	S	NW	SW	SW
1895	NW	W	NE	NE	S	NE	NE	SW	S	SW	S	S	NE
1896	S	W	N	S	S	NE	NE	S	NE	N	W	W	S
1897	W	W	SE	NE	N	NE	N	N	NE	SE	S	W	W
1898	W	S	S	N	NE	NE	NE	NE	NE	S	SW	W	S
1899	SW	W	NW	NE	NE	SW	NE	NE	NE	S	NE	W	NE
1900	W	W	SW	NE	NE	NE	SW	SW	S	S	W	W	W
1901	NW	W	SW	NE	NE	S	NE	NE	S	W	NW	W	NE
1902	W	W	S	NW	NE	NE	SW	NE	S	W	SW	W	NE
1903	W	W	SW	NE	S	NE	NE	SW	S	W	W	W	SW
1904	NW	NE	NW	NE	NE	NE	SW	NE	SW	SW	SW	SW	NE
1905	NW	NW	NE	NE	NE	NE	SW	SW	SW	SW	W	SW	SW
1906	SW	S	NE	SW	SW	SW	N	SW	SE	NW	W	NW	SW
1907	NW	NW	NE	NW	NE	SW	SW	NE	SW	SW	NW	SW	SW
1908	SW	NW	SW	SW	W	SW	SW	NE	SW	SW	W	W	SW
1909	SW	SW	NW	SE	NE	NE	NE	NE	NE	W	S	W	NE
1910	W	SW	SW	SW	NE	N	SW	S	SW	SW	W	W	SW
1911*	S	SW	S	NE	SW	SW	SW	NE	NE	W	W	SW	SW
1912*	W	W	NE	SW	S	SW	SW	SW	SW	SW	SW	SW	SW
1913*	S	W	S	N	NE	SW	NE	NE	SE	W	SW	SW	SW
1872–80	SW	SW	SW	NE	SW	SW	SW	SW	SW	SW	SW	SW	SW
1881–90	SW	SW	N	N	N	N	SW	SW	S	S	S	SW	SW
1891–1900	W	W	NE	NE	NE	NE	NE	NE	NE	S	SW	W	NE
1901–10	NW	NW	SW	NE	NE	NE	SW	NE	SW	SW	W	W	SW
1872–1910	SW	SW	SW	NE	NE	NE	SW	NE	SW	SW	SW	SW	SW

* Not included in means.

In Table CXXVIII the prevailing wind direction for the total period, southwest, differs from that of Table CXXXV, northeast, as the period covered by the latter is 20 years shorter. See also note under Table CXXXIV.

which affect the temperature of Chicago pass the city to the west and south, and in some cases the cold is ushered in and maintained by winds blowing from west to southwest, but the usual direction of the cold-wave wind is northwest. Except in winter cold-wave conditions,

however, the north wind is generally colder than winds from west through south to east, and the average temperatures of most of the months in which north winds prevailed were below the normal for the period; but the prevailing yearly direction of north recorded for the particular years in question was not so much on account of the great frequency of north winds, as it was because of the comparative infrequency of winds from any other one direction. In three of the years, north was the prevailing direction in only 4 months each, other directions being somewhat equally distributed through the remaining months.

TABLE CXXVIIIa

FREQUENCY OF MONTHLY PREVAILING WIND DIRECTIONS, 1872–1912

	NW	W	SW	S	SE	E	NE	N
January	8	12	16	5	0	0	0	0
February	3	14	14	4	1	0	4	1
March	6	4	10	4	1	0	11	5
April	2	0	9	1	1	0	20	8
May	0	3	5	4	0	2	20	7
June	0	0	15	3	1	0	16	6
July	0	0	21	1	1	1	12	5
August	0	0	14	6	0	2	16	3
September	0	0	17	10	2	2	9	1
October	1	5	17	11	1	0	3	3
November	5	12	12	10	1	0	1	0
December	1	15	21	2	2	0	0	0
Annual	0	2	23	4	0	0	8	4
Total	26	65	171	61	11	7	112	39
Percentage of total	5	13	35	12	2	2	23	8

In Table CXXVIIIa the prevailing wind direction as shown above, southwest, differs from that in Table CXXXV, northeast, as the data included above are for a period of 41 years, while in Table CXXXV only 19 years are included.

In regard to the months individually, the prevailing direction of southwest is also most frequent, as will be seen in Table CXXVIII*a*, which gives for each month the number of prevailing directions from each of the eight principal points of the compass. For the whole period southwest was the prevailing monthly direction 171 times, and northeast is next in order with 112. These two directions take up 58 per cent of the total record. The southwest wind has been the prevailing direction in all months of the year, but that from the northeast has never been the prevailing wind in December or January, and it has but seldom been recorded as such in November or February. Beginning with March, however, its frequency increases through May, and it remains prominent during the summer months, driving the high temperatures from the lake shore (pp. 37, 142), and establishing the reputation of the city as a summer resort.

Southwest and south winds are, of course, on the average warmer than those of any other direction, because they approach the city from the broad land expanse of the interior; and northerly winds are marked by relatively low temperatures (p. 145). However, the prevailing direction of any month cannot be taken as a certain indication of the general character of the temperature conditions during that period. For instance, while March, 1910, the prevailing wind direction of which was southwest, was the warmest March on record, the prevailing direction of the warmest July, that of 1901, was northeast, and the prevailing direction of the coldest July of official record, 1891, was southwest. In March, 1910, southwest winds prevailed for an average of 23 hours each day; in July, 1901, northeast winds were the prevailing winds for a daily average of 13 hours, southwest for 9 hours, and south for 2 hours. Hourly records of wind direction for July, 1891, are not available. Where, however, the prevailing direction for the month is, on the average, the prevailing direction also for most of the 24 hours of the day, the influence of the wind shows plainly in the temperature conditions. Such a case was March, 1910, mentioned above; and January, 1893, a very cold month, in which the prevailing wind direction was northwest for an average of 23 hours each day.

TOTAL WIND MOVEMENT, MONTHLY AND ANNUAL

Table CXXIX contains the total wind movement by months and years from 1873 to 1913, inclusive. It is apparent that the movement and the resulting velocities are greater in winter than in summer. The values obtained at one location, however, are not comparable with those of another. For instance, the average hourly velocity for the period of 15 years at the Major Block is 8.3 miles, while for the 3 years following at the Chicago Opera House Building, the average is 10.4 miles. The elevation of the anemometer at the two places was 103 and 153 feet, respectively. From February, 1890, to June, 1905, inclusive, with an elevation of 274 feet, the average hourly velocity at the Auditorium Tower was 17.2 miles, but at the still higher exposure at the Federal Building, 310 feet, from July, 1905, to December, 1910, inclusive, the average velocity was 14.3 miles an hour, or 2.9 miles less than at its preceding location, where the elevation was 36 feet lower. While, of course, wind velocities do not necessarily average the same for different periods of years, even if the registering instrument remains in the same position, and with no change in the sur-

rounding objects, there can be no doubt that the great differences in average hourly velocity shown in the figures just quoted are in a large measure due to just such changes. We should ordinarily expect the velocity at the Federal Building, on account of the higher elevation of its exposure, to be greater than that at the Auditorium Tower, but instead it averages somewhat lower. Up to the time the office was removed from the Auditorium, however, its tower was a comparatively isolated structure and there was a free approach to the anemometer from all sides. On the other hand, the dome of the Federal Building, upon which the instrument is now located, although rising above the former exposure, is yet in a way hemmed in by surrounding buildings of nearly the same height, and the movement of the wind is retarded by these obstructions. A comparison in detail is made below between synchronous records obtained at the Auditorium Tower and the Federal Building.

An anemometer records merely the velocity of the wind at the point where it is stationed, and it is by no means a measure of the force of the wind in any other place of dissimilar conditions. Comparative wind velocities at a single location, however, are of value, because the higher the wind at any place, the higher it is likely to be at some point close by, and the variation of the record of velocities during storms furnishes useful information as to the relative severity of the storm.

Fig. 59 shows, by months and years, the relative force of the wind at the four locations occupied by the Weather Bureau office. The records from which the graph was drawn do not cover synchronous periods, so that some degree of the variation must be charged directly to actually differing velocities in the general current.

For the six months from July 1, 1905, to December 31, 1905, registers were maintained at both the Auditorium Tower and the Federal Building, and the relative movements for the different locations are illustrated in Fig. 60. For all directions the average movement at the Federal Building is only 90 per cent of that at the Auditorium Tower. It is less than 90 per cent from northeast through east to southwest. The Auditorium is situated near the lake, and there is practically nothing between to obstruct the passage of the wind, and to the south and southwest at the time of the Weather Bureau's occupancy of the tower all buildings in the business district were much lower, so that the flow of air at the level of the anemometer was but little held back by surface friction. Buildings interfered

TABLE CXXIX

Total Wind Movement, Annual and Monthly, Miles, 1873–1913

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total	Monthly Mean	Average Daily Movement	Average Hourly Movement
1873	[a]8175	....	[d]7336	[f]7428	[c]6960	[b]4752	5854	4549	[b]6517	[c]5527	[c]4620	6866	(11 mo.) 68584	6235 6761	204	8.9
1874	7072	5481	7782	7465	7071	6122	6936	6754	5877	6321	7027	7220	81128		222	9.3
1875	5876	[b]6618	[a]5438	6986	6986	6014	5275	6329	[g]3628	7632	6559	[h]6757	74098	6175	203	8.9
1876	6730	5968	7005	6539	6328	5530	5145	4219	4980	6357	5490	5896	70187	5849	192	8.0
1877	6745	6430	7756	6746	6290	5870	5172	4942	5571	6801	6784	6847	75954	6330	208	8.7
1878	7153	[c]5769	[e]6982	6465	5044	4613	4562	4550	5322	6613	4843	5236	67152	5596	184	7.7
1879	5040	5136	5362	5689	5509	4992	4604	4745	4972	4549	[h]5210	[e]5886	61694	5141	169	7.1
1880	5277	5975	6872	8153	6128	5113	5002	5748	6034	6927	6614	6334	74177	6181	203	8.4
1881	5447	5611	5842	5001	5583	5767	4848	5507	5894	5772	7620	6615	69507	5792	190	8.0
1882	6929	6623	7768	7266	7234	5940	5580	4996	5697	5733	6123	6371	76260	6355	209	8.7
1883	7149	5851	6707	7318	6711	5967	5902	4511	4776	5931	6436	5952	73211	6101	201	8.4
1884	6706	5426	6172	6367	6014	4479	4293	4998	5803	5751	5382	6473	67864	5655	186	7.7
1885	7281	4922	5527	6319	5400	4636	4229	6095	5727	6138	6181	6711	69166	5764	189	8.0
1886	7499	6901	6853	6148	5752	4932	5472	5431	5535	5992	6924	5111	72550	6046	199	8.3
1887	9329	7431	8271	8786	6915	6463	7161	6579	7849	9025	9192	([z])	(11 mo.) 87001	7909	260	10.8
1888	8294	7702	8931	9112	7507	7383	6450	7730	6670	8210	7404	8360	93753	7813	256	10.6
1889	7807	7394	7985	7936	9771	5614	5979	5290	5609	7096	7488	7664	85633	7136	235	9.8
1890	7978	12105	13806	14912	13538	9225	11503	10297	12436	10751	12224	13582	142357	11863	390	16.3
1891	11142	13357	14319	12043	11865	9961	9670	9228	10184	12899	14425	15935	145028	12086	397	16.6
1892	14502	11609	14249	16002	13382	9535	10096	10259	11092	12622	12843	11657	147848	12321	405	16.8
1893	12462	13979	14836	17231	13961	10451	10519	11339	13601	13993	12644	16387	161403	13450	442	18.4
1894	14149	14023	16485	9739	13450	10654	11020	10588	11680	12272	12401	14151	150612	12551	413	17.2
1895	13444	12343	14885	13162	12903	9847	10627	9855	13488	12824	13904	13951	151233	12603	414	17.3
1896	11771	13824	13725	14265	13729	10228	11065	10489	11878	12306	14050	11904	149234	12436	409	17.0
1897	13912	11158	14416	14654	12155	10844	9963	11209	11338	12436	14303	13573	149961	12497	411	17.1
1898	13236	13039	13046	13477	12795	10985	9827	10876	11479	13650	15250	14814	152474	12706	418	17.4
1899	14558	12163	13696	12473	12819	11600	9165	10278	12167	13122	12340	13758	148139	12345	406	16.9
1900	13343	12809	13797	12479	12114	10459	11471	9958	11517	11344	12574	13319	145184	12099	398	16.6
1901	13729	11162	15318	13283	11825	10470	11231	10233	11882	13420	10983	11657	145193	12099	398	16.6
1902	12736	10279	13999	12820	12356	10902	10274	9839	11834	13148	13583	15476	147246	12270	403	16.8
1903	13162	12662	12662	15289	13137	9729	10425	10740	11898	12468	12200	13240	147572	12298	404	16.9
1904	12614	12998	12761	13081	11828	10533	10739	10672	11754	12696	11732	15265	146673	12223	402	16.7
1905	13278	12065	13318	11362	11878	8717	9361	8610	9871	11717	13014	11663	134854	11238	369	15.4
1906	12998	10460	12947	9956	11414	10188	7977	8312	9384	11662	10471	11359	127128	10594	348	14.5
1907	10662	9952	12233	12155	11162	9800	8584	9186	9416	10842	10520	11559	126071	10506	345	14.4
1908	12930	12860	11719	12454	11344	10461	8552	9089	9105	10670	11503	12064	132751	11063	364	15.1
1909	9946	11644	10828	12556	11664	8006	8756	7951	8707	10903	12476	12278	125715	10476	344	14.3
1910	11684	10864	10921	10481	10066	7612	8775	9019	7619	8342	9377	10888	115648	9637	317	13.2
1911*	11710	10518	11706	9677	9745	8416	8805	8044	8248	9507	12174	10726	119276	9940	327	13.6
1912*	10595	10040	10079	11907	10500	7428	8049	8235	8030	9446	11052	12263	117624	9802	321	13.4
1913*	11191	9792	13172	10239	9998	8625	8489	7921	8491	9097	10468	8665	116148	9679	318	13.2

Average for exposure at Major Block from June, 1873, to December, 1886, inclusive	6531	5848	6695	6651	6158	5383	5205	5241	5516	6194	6332	6306	72060	6005	197	8.3
Average for exposure at Chicago Opera House Building from January, 1887, to January, 1890, inclusive	8352	7509	8396	8611	8064	6487	6530	6533	6709	8110	8028	8012	91341	7612	250	10.4
Average for exposure at Auditorium Tower, February, 1890, to June, 1905, inclusive	13203	12473	14082	13517	12733	10259	10506	10391	11882	12663	13030	13911	148650	12388	407	17.2
Average for exposure at Federal Building, July, 1905, to July, 1910, inclusive	11644	11156	11730	11520	11130	9213	8668	8694	9017	10689	11227	11634	126322	10527	346	14.3

Table CXXIX shows the total monthly and annual wind movement, the average monthly and daily wind movement, and the average hourly wind velocity, 1873-1913, together with the averages for each of the above for the four different locations of the Weather Bureau.

* Not included in averages. [b] 27 days. [d] 20 days. [f] 28 days. [h] 29 days.
[a] 24 days. [c] 26 days. [e] 30 days. [g] 19 days. [s] Record incomplete.

SUMMARY OF TABLE CXXIX

Average Monthly Wind Movement, Miles

Station	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Major Block	6531	5848	6695	6651	6158	5383	5205	5241	5516	6194	6332	6306	72060
Chicago Opera House	8352	7509	8396	8611	8064	6487	6530	6533	6709	8110	8028	8012	91341
Auditorium Tower	13203	12473	14082	13517	12733	10259	10506	10391	11882	12663	13030	13911	148650
Federal Building	11644	11156	11730	11520	11130	9213	8668	8694	9017	10689	11227	11634	126322

Average Hourly Wind Velocity, Miles

Station	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Major Block	8.8	8.8	9.1	9.3	8.3	7.5	7.0	7.0	7.8	8.4	8.6	8.5	8.3
Chicago Opera House	11.2	11.0	11.3	12.0	10.8	9.0	8.8	8.8	9.3	10.9	11.2	10.8	10.4
Auditorium Tower	17.7	18.4	18.9	18.8	17.1	14.2	14.1	14.0	16.5	17.0	18.1	18.7	17.2
Federal Building	15.7	16.5	15.8	16.0	15.0	12.8	11.6	11.7	12.5	14.4	15.6	15.6	14.3

more with the course of the wind from the north, however, and the difference between the velocities of the two locations was somewhat less from that direction; while from the northwest and west the movement at the Federal Building was somewhat the higher, because winds from these directions must, before reaching the Auditorium, pass over the structures beyond the Federal Building, and in addition over several others between the two.

While the average wind movement during the 6-months period showed 90 per cent for the present location, the comparison of the

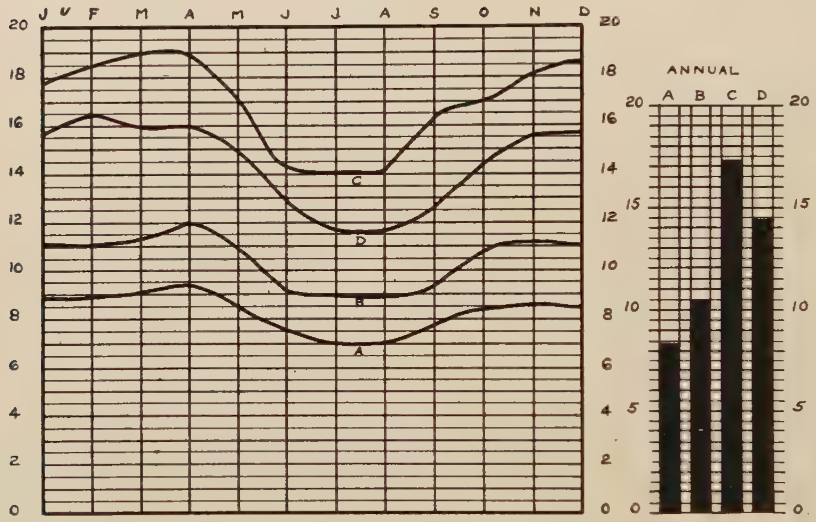


Fig. 59.—Average hourly wind velocity.

A=Major Block, elevation 103 ft. above ground; B=Chicago Opera House, elevation 153 ft. above ground; C=Auditorium Tower, elevation 274 ft. above ground; D=Federal Building, elevation 310 ft. above ground.

latter for the period from July, 1905, to December, 1910, with that of the 15-year period at the Auditorium, is only 85 per cent. This increased difference between the averages of the two places doubtless is due for the most part to a decrease in wind velocity at the Federal Building on account of the large number of skyscrapers that have been erected near it since 1905.

Further information as to the effect of exposure on the movement of wind is afforded by a short record maintained at the storm warning tower near the Life Saving Station on the breakwater at the mouth of the Chicago River, beginning with August, 1911. The

anemometer here was located 60 feet above the surface of the lake about $1\frac{1}{2}$ miles from the Federal Building, where the official instrument is placed, 310 feet above the ground, and 323 feet above the lake. The difference in elevation is therefore 263 feet, and yet,

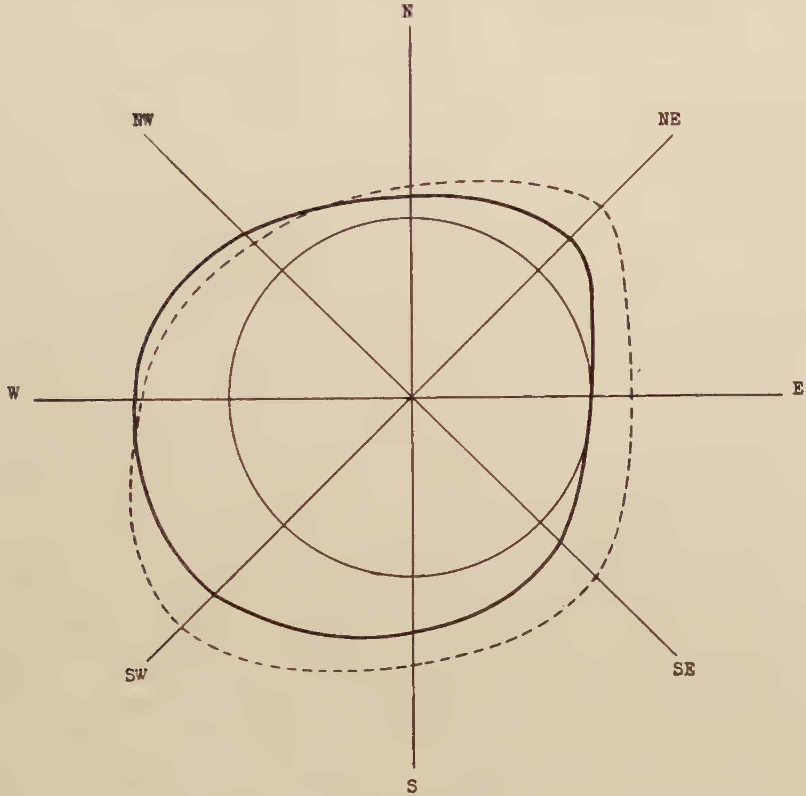


Fig. 60.

Total movement, all directions, Federal Building 310 ft. elevation : Total movement, all directions, Auditorium 274 ft. elevation :: 90:100

Fig. 60 contains a wind rose based upon the wind movement from all directions during the same period at both the Auditorium Tower and the Federal Building, the dotted curve representing the Auditorium record and the solid black curve the record at the Federal Building. The relation between the two records is expressed beneath the wind rose in the form of a proportion.

with the exception of west and northwest winds, the movement at the breakwater is almost uniformly higher than that at the Weather Bureau office. The average velocity for the year ending July, 1912, was 13.4 miles an hour for the Federal Building and 14.1 miles an

hour for the anemometer at the breakwater. The greatest difference was in March, when the movement of the former was but 90 per cent that of the later, but in the following May it was slightly in excess. While the anemometer at the breakwater had only a moderate elevation, it suffered from no obstructions near by in any direction, while the position on the dome of the Federal Building is affected by surrounding high structures.

AUXILIARY TABLE L

COMPARISON OF WIND VELOCITIES AT THE FEDERAL BUILDING AND AT THE BREAKWATER, CHICAGO, AUGUST, 1911, TO JULY, 1912

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Mean
Federal Building...	10.8	11.5	12.8	16.9	14.4	14.2	14.4	13.5	16.5	14.1	10.3	10.8	13.4
Breakwater.......	11.3	12.1	13.8	17.2	15.1	14.5	15.7	15.0	17.2	14.0	11.0	11.9	14.1
Percentage.......	96	95	93	98	95	98	92	90	96	101	94	91	95

The data above are based upon calculations involving the total wind movement from all directions, and give the average velocities at the Federal Building to be 95 per cent of those at the breakwater. There is a great difference, however, in the velocities at the two places when the wind is from the free surface of the lake, the official anemometer recording a much lower velocity; while with winds from the west and northwest, which must pass over the structures of the city before reaching the breakwater, the velocity is slightly higher at the Weather Bureau office, as the anemometer there is reached first. The figures below indicate this variation nicely. Two days each of lake and land winds have been selected, with light and moderate winds in each pair, and with conditions of cloudiness nearly equal, and the results are given in Auxiliary Table M.

AUXILIARY TABLE M

COMPARISON OF WIND VELOCITIES AT THE FEDERAL BUILDING AND AT THE BREAKWATER, CHICAGO, LAKE AND LAND WINDS

Lake Winds (NE)				Land Winds (NW)			
Date	Federal Building	Break-water	Per-centage	Date	Federal Building	Break-water	Per-centage
February 20, 1912....	14.1	17.2	82	January 15, 1912.....	20.3	19.5	104
April 17, 1912........	21.0	33.1	63	February 9, 1912.....	12.2	11.8	103

With winds from the lake the excess in velocity of the location on the breakwater increases with high winds, as shown; and while there is but little variation with land winds, the velocity at the

Federal Building is the greater, although the difference is not large, and it increases but slowly as the wind rises. In each case above, the direction of the wind was as indicated for by far the greater portion of the day. It varied a little at the two locations, but in the illustration of the lake wind it was always from the water surface; and in that of the land wind, from the west during the small time it shifted from the northwest.

As a rule, with free exposures or with similar exposures, as has been indicated previously, the velocity increases with the altitude. In experiments made in the cranberry marshes of Wisconsin it was found that the velocity of the wind at 4.7 feet above the surface of the marsh averaged 4.5 miles an hour for an entire season, while that at an elevation of 50.5 feet, near by, averaged for the same time 9.0 miles (Cox, *Bulletin T*, United States Weather Bureau). Milham states that on the Eiffel Tower, 990 feet above the ground, the velocity is 3.1 times that recorded at an altitude of 60 feet (*Meteorology*, p. 145). It will thus be seen that the velocity of the wind depends largely upon altitude, buildings, and character of the surface passed over.

GREATEST DAILY WIND MOVEMENT, BY MONTHS

In Table CXXX are given the greatest wind movements occurring in any day of the month, for the total period of Auditorium Tower and Federal Building records. Previous records are so affected by the lower exposures of the anemometers that comparisons would be impracticable. Indeed, in making exact comparisons between the velocities of the two locations represented in the table, the Federal Building values, which begin with July, 1905, should be increased by at least 10 per cent. The greatest daily wind movement, 1,347 miles, occurred on February 12, 1894. The greatest at the present location was 952 miles on January 20, 1907. This record increased by the correction of 10 per cent would give only 1,047 miles, and would fall short of the Auditorium Tower record by about 300 miles.

HEAVY STORM WINDS

On the day of greatest wind movement given in the preceding paragraph, February 12, 1894, the wind attained a velocity for five minutes of 84 miles an hour from the northeast. The extreme velocity, or the fastest mile recorded, was at the rate of 115 miles an hour, and the storm averaged nearly 70 miles an hour for over

10 consecutive hours. Snow to the amount of about 10 inches fell continuously during this time, and was drifted badly by the wind. Business was much interrupted and much damage was done as a result of the extraordinary violence of this storm, which actually extended over 23 hours, beginning at 3 A.M.

TABLE CXXX

GREATEST DAILY WIND MOVEMENT FOR EACH MONTH AND FOR THE YEAR, 1890–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Highest for the Year
1890	......	712	944	866	670	695	685	603	685	676	587	756	944
1891	655	771	771	714	709	645	791	574	548	809	788	953	953
1892	768	693	713	981	731	507	605	622	602	672	781	675	981
1893	644	966	848	1,012	780	645	523	644	951	849	737	812	1,347
1894	824	1,347	859	737	882	693	657	493	606	606	830	737	1,012
1895	946	746	799	652	698	582	535	560	793	774	776	811	946
1896	660	731	865	804	844	635	577	575	602	743	805	642	865
1897	725	685	817	904	769	542	620	589	587	723	802	794	904
1898	861	650	691	911	697	713	600	642	591	876	1,077	776	1,077
1899	763	863	840	780	737	649	473	535	655	731	914	779	914
1900	627	877	753	716	663	587	645	492	816	718	842	871	877
1901	910	843	810	858	680	596	544	533	789	707	696	652	910
1902	710	670	786	917	644	596	638	539	722	801	719	832	917
1903	658	725	820	894	767	605	541	595	704	636	784	589	894
1904	736	734	579	763	641	647	602	505	623	640	698	888	888
1905	801	735	770	582	667	701	606	450	527	654	799	726	801
1906	771	707	719	576	674	550	433	496	659	685	710	658	771
1907	952	796	708	685	648	594	488	449	533	534	625	586	952
1908	597	775	757	720	708	619	526	445	577	612	739	665	775
1909	775	881	550	815	709	419	546	445	488	708	683	664	881
1910	686	607	678	642	646	476	480	557	454	474	593	569	686
1911	793	586	634	548	581	405	540	391	478	595	871	721	871
1912	603	733	698	759	682	412	380	504	490	564	578	575	759
1913	599	645	685	548	563	607	582	417	459	519	640	564	685
Highest for the month	952	1,347	944	1,012	882	713	791	644	951	876	1,077	953	1,374

Record from February 1, 1890, to June 30, 1905, at Auditorium Tower.
Record from July 1, 1905, to December 31, 1913, at Federal Building.

In the following May another severe storm occurred, which, although of less violence, yet caused great damage to vessels in the lake, as navigation was in full operation at the time. This was on May 18 and 19, 1894. The total wind movement for the first day was 882 miles, with a maximum velocity of 62 miles an hour from the east; on the second day the total movement was the same, 882 miles, and the maximum velocity was 48 miles an hour from the north. The storm was accompanied by rain mixed with snow, and although storm warnings had been hoisted at lake ports on the 17th, many wrecks occurred. It began about 7:30 A.M. on the 18th, and the wind averaged 50 miles an hour for the entire day. The blow was not as steady as that of the preceding February, but was gusty by fits and spells, blowing 30 miles an hour one minute and 60 miles

the next. Nine vessels were totally wrecked off Chicago, the number of casualties being unprecedented for any single storm, and considerable damage was wrought on shore. The gale did not subside until the afternoon of the 19th.

On April 20, 1893, the total wind movement was 1,012 miles, with a maximum of 72 miles an hour from the northeast. This storm was accompanied by heavy rain mixed with occasional snow flurries, and began on the morning of the day before, on which day the wind movement was 911 miles, with a maximum of 62 miles an hour from the east. On the 21st the wind movement was also high, being 844 miles, and the maximum was 50 miles from the southwest. The gale did not cease until about midnight of April 21, and during its course three vessels were wrecked in the lake, and much damage was done to buildings in the grounds of the Columbian Exposition, chiefly through breakage of glass.

The storm of November 9 and 10, 1898, was also severe. The total wind movements for the two days were 1,077 and 936 miles, respectively, and the maximum velocities were 50 and 61 miles an hour, in both cases from the northeast. The storm began about midnight of November 8 and extended over the 9th and until the evening of the following day. On the 7th preceding, a velocity of 76 miles an hour from the south occurred, the storm lasting from noon to midnight, but the direction of the wind was unfavorable to heavy seas, and comparatively little damage was done.

On the day of greatest movement at the present location of the Weather Bureau office, January 20, 1907, when 952 miles were recorded, the maximum velocity was 60 miles an hour from the west. Snow squalls occurred in connection with the storm, and its severity was intensified by very low temperature, the mercury being as low as 4° above zero at midnight.

The foregoing notes will indicate some of the more important facts regarding the force, duration, and direction of our greatest storm winds, and they may be used in connection with the instances of damaging snow, sleet, and ice storms discussed on pp. 224–27. Of course, the longer a storm continues, other things being equal, the greater is the likelihood of damage. Also, if the wind is onshore—that is, from an easterly direction—the sea along the Chicago shore is high, and damage to vessels, sea walls, piers, and abutments correspondingly great. Occasionally, when storms are of short duration, the wind movement for the day as a whole gives no indica-

tion of the high velocities during the blow. The highest wind velocities of the summer season usually occur in severe squalls of brief duration, ranging in length from a few minutes to an hour. Such an instance was that of May 25, 1903, when a maximum velocity of 72 miles an hour from the southwest was reached, although the total number of miles recorded within the same hour was but 32. An even greater difference occurred in the squall of July 5, 1897, when the maximum velocity was 72 miles an hour from the west, while the wind movement for the hour in which it occurred was only 22 miles, and the entire squall lasted but a few minutes.

MAXIMUM WIND VELOCITIES

The highest wind velocity for any period of five minutes, with its direction, is recorded as the maximum wind velocity for the month. Table CXXXI gives these data for each month from 1872 to 1913, inclusive. Due allowance must be made for changes in the location and elevation of the anemometer, as has already been explained (p. 282). The highest velocity of record is 84 miles from the northeast, in the storm of February 12, 1894, and the next highest is 76 miles from the south, on November 7, 1898, both of which have been referred to above. Several dates are shown in the table on which velocities of 72 miles occurred. These high velocities are not from any one direction, but it will be noted that most of them are from the northeast or southwest in the winter and from the southwest in the warmer months. The most severe blows of the year are the northeast snow winds of winter. In the summer southwest winds the temperature is usually rising, and the velocities are increased by the effect of the thermal gradient upon the barometric pressure. The blow in such high winds from the southwest is ordinarily quite steady, but when high winds occur in the heated season, blowing from the west and northwest, they are usually the accompaniment of thunder squalls, and are of comparatively brief duration.

FREQUENCY OF GALES

Table CXXXII shows the monthly and annual frequency of gales from February, 1890–1913, inclusive. By a gale is meant a wind of the velocity of 40 miles an hour or over. In the study of this table, also, allowance must be made for the change of the anemometer from the Auditorium Tower to the Federal Building in July, 1905. In Fig. 61, which shows the same data graphically, it will readily be

MAXIMUM WIND VELOCITIES IN MILES PER HOUR, 1872–1913

Year	January Velocity	January Direction	January Date	February Velocity	February Direction	February Date	March Velocity	March Direction	March Date	April Velocity	April Direction	April Date
1872..	27	NW	13	37	W	13	34	SW	18	46	NE	15
1873..	48	......	..	38	......	.	32	......	.	32	......	2
1874..	30	......	..	36	SW	23	30	SW	7	30	N	8
1875..	25	NW	8	40	W	3	38	SW	15	30	N	29
1876..	40	N	1	22	S	5	35	NE	28	30	W	5
1877..	26	NE	15	28	N	23	32	N	8	36	SW	1
1878..	23	NE	31	28	NE	9	35	S	5	36	S	10
1879..	26	SW	24	22	NW	1	25	SW	24	26	SW	10
1880..	29	W	9	32	W	28	27	NE	12	36	SW	15
1881..	26	E	31	26	N	27	35	NE	19	21	NW	1
1882..	30	SW	26	27	NE	20	32	W	21	28	NE	9
1883..	27	SW	13	24	SW	16	28	NE	18	33	NE	22
1884..	26	W	30	26	W	19	28	SW	11	36	W	27
1885..	22	SW	26	24	NE	8	28	SW	9	24	N	2
1886..	28	W	16	29	SW	25	20	SW	8	30	NW	6
1887..	33	NW	28	42	W	26	35	N	2	38	SW	23
1888..	37	SW	1	45	SW	20	37	W	21	37	SW	13
1889..	44	SW	17	32	SW	19	40	N	18	36	SW	24
1890..	42	NW	8	48	W	5	68	NE	27	56	SW	12
1891..	54	NE	2	60	SW	24	56	SW	15	50	SE	20
1892..	60	NW	1	55	SW	7	57	SW	9	65	N	14
1893..	49	SW	8	60	SW	28	56	SW	24	72	NE	20
1894..	51	S	20	84	NE	12	61	NW	10	52	SW	30
1895..	64	SW	21	51	SW	20	50	NE	3	40	E	11
1896..	44	S	11	48	W	10	57	S	21	60	S	18
1897..	62	W	17	51	E	22	49	E	31	67	S	18
1898..	66	NE	22	48	NE	15	62	W	28	48	NE	5
1899..	52	W	26	48	SE	26	58	SW	12	60	S	28
1900..	48	SW	24	70	SW	8	53	SW	6	46	NE	8
1901..	53	S	20	58	NE	3	56	SE	13	56	NE	21
1902..	48	S	17	50	W	4	57	W	16	70	SW	25
1903..	46	W	30	50	S	22	52	SW	24	53	S	2
1904..	54	NE	2	48	W	2	52	W	24	53	SW	24
1905..	46	W	15	47	SW	27	54	S	28	58	W	29
1906..	56	SW	3	54	SW	3	49	NW	21	40	S	13
1907..	60	W	20	50	NW	2	48	W	29	48	SW	24
1908..	44	NW	26	54	W	5	54	W	6	52	W	25
1909..	48	NW	29	48	NE	14	38	W	16	60	W	7
1910..	48	W	26	48	W	15	50	W	6	40	NW	22
1911..	62	SW	8	48	E	5	48	W	27	46	W	15
1912..	41	W	9	53	N	21	43	NE	20	51	S	26
1913..	37	NE	7	46	W	22	52	SW	24	37	SW	3
Highest..		66			84			68			72	
Direction		NE			NE			NE			NE	
Year.. Day..		1898 22			1894 12			1890 27			1893 20	

Year	May Velocity	May Direction	May Date	June Velocity	June Direction	June Date	July Velocity	July Direction	July Date	August Velocity	August Direction	August Date
1872..	25	SW	26	..	......	.	..	......	.	..	......	..
1873..	36	......	22	30	......	.	20	......	..	18	......	..
1874..	25	NE	3	26	W	12	30	NE	24	25	......	..
1875..	30	SW	8	25	NW	23	30	NE	15	45	S	5
1876..	45	SW	6	36	NE	23	24	NW	5	20	......	.
1877..	26	N	20	50	NW	25	25	N	5	22	SW	31
1878..	25	W	2	25	S	2	25	E	26	22	SW	8
1879..	25	N	31	26	N	2	20	W	7	20	S	12
1880..	28	SW	9	36	SW	7	24	SW	25	24	NE	2
1881..	24	W	14	32	SW	29	20	NW	24	20	SW	30
1882..	27	NE	6	24	SW	18	21	SW	27	16	SW	12
1883..	32	S	18	25	W	19	21	SW	16	20	SW	20
1884..	25	NW	27	23	NW	9	28	NE	23	20	SW	25
1885..	30	SW	8	24	N	13	26	N	28	27	N	2
1886..	22	NW	6	20	NW	7	23	NE	7	24	NW	16
1887..	44	SW	2	34	W	18	30	W	17	30	W	11
1888..	44	SW	4	30	SW	13	39	NE	12	40	NW	2
1889..	48	N	31	28	NW	19	36	SW	27	25	SW	8
1890..	59	NE	10	53	SW	5	52	NE	4	45	S	8
1891..	51	S	9	45	E	6	50	NE	2	48	NE	23
1892..	60	SW	3	72	NW	13	45	SW	2	40	S	8
1893..	50	S	22	50	NE	1	40	S	28	50	NE	28
1894..	62	E	18	50	SW	26	50	SW	12	43	SE	11
1895..	50	N	13	40	NW	25	50	W	18	45	S	23
1896..	62	S	25	50	SW	7	36	NE	15	36	NW	11
1897..	49	N	2	55	S	2	72	W	5	56	NE	1
1898..	48	W	19	50	SW	24	48	N	19	72	SW	16
1899..	56	S	28	48	NE	28	37	NE	16	54	NW	11
1900..	43	NE	8	44	SW	10	49	SW	15	45	SW	15
1901..	48	NE	24	54	S	5	56	SE	18	44	S	2
1902..	54	NE	25	45	NE	29	69	SW	17	47	S	20
1903..	72	SW	25	35	E	2	70	S	4	56	SW	5
1904..	42	SW	22	50	SW	4	44	SE	27	42	SW	9
1905..	48	SW	14	41	NE	26	40	SW	4	43	W	5
1906..	48	SW	12	56	NW	29	42	NW	28	41	W	9
1907..	40	SW	12	42	W	22	43	W	25	44	SW	6
1908..	68	W	28	45	SW	8	41	SW	6	49	SW	12
1909..	50	SW	15	48	SW	22	42	NW	22	32	NE	31
1910..	50	NE	2	40	W	18	42	W	12	60	NE	23
1911..	38	S	19	34	SW	4	48	W	24	36	NW	14
1912..	43	N	12	41	W	4	33	SW	13	32	SW	24
1913..	44	NE	14	38	N	7	47	NE	8	35	SE	8
Highest..		72			72			72			72	
Direction		SW			NW			W			SW	
Year.. Day..		1903 25			1892 13			1897 5			1898 16	

Year	September Velocity	September Direction	September Date	October Velocity	October Direction	October Date	November Velocity	November Direction	November Date	December Velocity	December Direction	December Date	Annual Greatest Velocity	Annual Greatest Direction	Annual Greatest Date
1872..	50	......	24	31	......	30	31	......	13	32	......	14	50	......	Sept. 24
1873..	35	......	17	35	......	..	32	......	..	40	......	5	48	......	Jan. ..
1874..	30	......	..	35	......	..	35	W	23	40	......	.	40	......	Dec. ..
1875..	35	N	9	32	SW	25	25	NE	13	26	W	12	45	S	Aug. 5
1876..	20	W	28	28	SW	10	25	SW	6	34	W	16	45	SW	May 6
1877..	26	NE	10	33	NE	19	32	N	9	24	SW	15	50	NW	June 25
1878..	28	SW	25	27	SW	16	26	SW	2	27	W	3	36	S	April 10
1879..	28	NW	16	20	NW	2	26	S	24	25	SW	10	28	NW	Sept. 16
1880..	23	S	15	30	SW	16	28	W	11	32	W	5	36	SW	April 15
1881..	27	SW	24	23	SW	15	28	SE	11	26	SW	26	35	NE	Mar. 19
1882..	21	NE	11	27	SW	30	24	NE	2	28	W	4	32	W	Mar. 21
1883..	21	N	16	21	E	25	26	W	11	26	NW	27	33	NE	April 22
1884..	24	W	17	35	N	8	22	NW	23	29	SW	31	36	W	April 27
1885..	25	S	8	24	NE	19	24	W	13	26	NW	5	30	SW	May 8
1886..	22	NW	18	37	SW	14	32	SW	18	27	NW	14	37	SW	Oct. 14
1887..	36	E	27	44	W	3	36	SW	18	.	......		44	W	Oct. 3
1888..	27	N	25	34	SW	19	38	SW	5	41	S	26	45	SW	Feb. 20
1889..	28	NW	17	32	NE	25	37	W	28	36	NW	29	48	N	May 31
1890..	49	NW	19	50	SW	13	45	SW	5	54	SW	13	68	NE	Mar. 27
1891..	40	SW	28	46	NE	26	51	S	19	57	SE	1	60	SW	Feb. 24
1892..	40	SW	10	58	NW	28	55	SW	7	50	SW	7	72	NW	June 13
1893..	60	SE	29	60	SW	6	51	SW	17	53	SW	15	72	NE	April 20
1894..	48	S	22	48	SW	3	60	SW	20	60	SW	16	84	NE	Feb. 12
1895..	53	S	4	56	SW	18	53	S	27	54	NE	11	64	SW	Jan. 21
1896..	42	N	30	62	S	29	53	W	27	47	S	25	62	S	May 25
1897..	39	NE	26	47	SW	14	55	SW	10	56	SW	16	72	W	July 5
1898..	41	E	22	63	SE	17	76	S	7	47	S	26	76	S	Nov. 7
1899..	47	W	28	53	S	10	48	NE	2	56	SW	12	60	S	April 28
1900..	72	SW	11	48	NE	16	50	NE	24	52	SW	23	72	SW	Sept. 11
1901..	48	W	15	50	S	11	50	S	6	48	S	13	58	NE	Feb. 3
1902..	52	SW	8	58	S	13	52	SW	23	58	NE	2	70	SW	April 25
1903..	51	S	12	50	S	7	69	S	12	52	SW	27	72	SW	May 25
1904..	46	SW	25	53	SW	4	47	SE	28	72	SW	27	72	SW	Dec. 27
1905..	38	NW	1	48	W	19	52	SW	24	46	W	29	58	W	April 29
1906..	46	N	29	50	NW	27	59	SW	21	39	SW	31	59	SW	Nov. 21
1907..	40	NW	24	41	W	9	52	SW	20	42	NE	14	60	W	Jan. 20
1908..	39	W	30	36	SW	16	46	W	26	52	W	30	68	W	May 28
1909..	36	W	14	46	W	12	48	W	16	52	SW	5	60	W	April 7
1910..	35	SE	4	46	S	3	39	W	23	37	S	31	60	NE	Aug. 23
1911..	59	SW	18	44	W	4	48	S	11	47	S	10	62	SW	Jan. 8
1912..	32	W	25	40	W	12	40	W	8	45	SW	6	53	N	Feb. 21
1913..	32	W	20	36	NE	27	42	NW	9	38	NW	7	52	SW	Mar. 24
Highest..		72			63			76			72			84	
Direction		SW			SE			S			SW			NE	
Year.. Day..		1900 11			1898 17			1898 7			1904 27				1894 Feb. 12

Table CXXXI shows the maximum wind velocity for each month and year from 1872 to 1913, together with direction and date. By reference to Table CXXIX, the length of the record at the different locations may be seen.

seen that the number of gales of 40 miles an hour or over has been much smaller since the removal to the present location, and this is

TABLE CXXXII

MONTHLY AND ANNUAL FREQUENCY OF GALES, 1890–1913

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1890........	......	5	5	14	11	7	3	2	5	5	5	4	66
1891........	3	9	9	8	5	2	6	1	1	8	10	13	75
1892........	7	2	11	11	6	4	2	1	1	3	8	3	59
1893........	4	6	10	14	8	3	1	3	5	7	7	11	79
1894........	6	6	13	6	11	4	2	1	1	1	5	5	61
1895........	4	3	8	3	3	1	6	1	7	5	7	5	53
1896........	3	8	8	10	7	2	0	0	5	4	7	2	56
1897........	4	7	8	12	6	4	2	4	0	1	8	10	66
1898........	7	7	9	6	5	3	2	2	2	6	10	5	64
1899........	5	3	7	8	5	4	0	2	4	3	3	6	50
1900........	3	6	6	4	2	1	6	4	4	5	9	7	57
1901........	6	3	11	4	4	8	4	1	3	5	3	2	54
1902........	5	2	6	6	7	5	5	1	4	8	5	9	63
1903........	4	3	6	11	5	0	2	2	2	3	4	3	45
1904........	5	7	5	7	2	2	5	2	5	4	5	11	60
1905........	5	4	5	5	5	1	1	1	0	3	7	1	38
1906........	5	3	3	2	5	3	1	1	3	3	3	0	32
1907........	3	2	3	4	1	2	2	3	1	1	2	1	25
1908........	2	8	3	5	4	2	1	3	0	0	4	1	33
1909........	3	4	0	9	6	1	1	0	0	2	6	2	34
1910........	2	1	3	2	3	1	1	2	0	2	0	0	17
1911*.......	4	4	4	1	0	0	3	0	1	5	5	3	30
1912*.......	1	3	1	3	3	1	0	0	0	1	1	2	16
1913*.......	0	1	4	0	2	0	3	0	0	0	2	0	12
Average.....	4	5	7	7	5	3	3	2	3	4	6	5	52

* Not included in averages.

Table CXXXII gives the number of times each month and year during which the wind reached or exceeded a velocity of 40 miles an hour. In the study of this table, allowance should be made for the change in exposure of the anemometer as noted in Table CXXX (see Fig. 61).

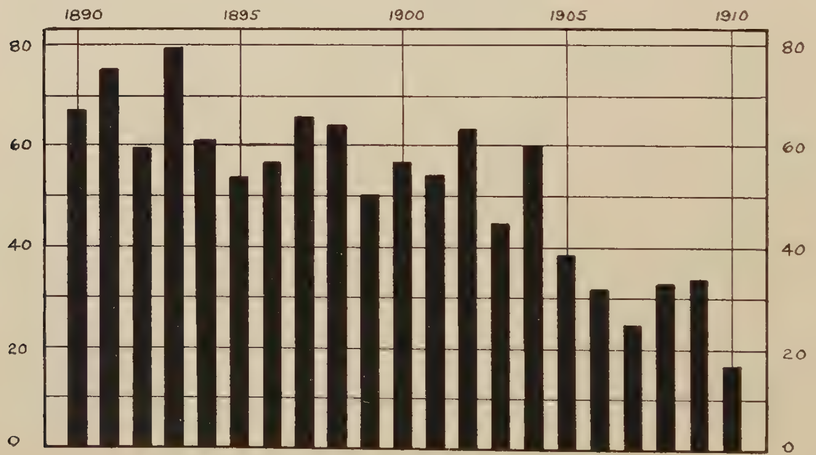


FIG. 61.—The frequency of storm winds.

Fig. 61 shows graphically the number of times each year during which the wind has reached or exceeded a velocity of 40 miles an hour (see Table CXXXII). The decrease since the change to the Federal Building in 1905 is striking.

more because of the change in the position of the wind-recording instrument than because of any lessening in the frequency of storms. While the definition of "gale" as a wind of 40 miles an hour or over has remained the same in the language of the Weather Bureau, it has been found necessary to lower the limit which in the Auditorium Tower records marked the occurrence of a storm, so as to equalize the issuance of storm warnings in anticipation of storm winds as recorded at the Federal Building. The verifying velocity at the former location was even above that defined as a "gale," and was fixed at 46 miles an hour. Since the removal, however, it has been successively lowered to 40 and to 36 miles an hour, the latter being the present verifying velocity for storm winds at Chicago. The table shows 1893 to be the stormiest year of the record, there having been 79 gales in that year. Of the months, 14 gales occurred in April, 1890, and in the same month in 1893, and such winds are more frequent in March and April, and least frequent in August.

Storm winds do not occur with the same frequency from all points of the compass, and there are several reasons underlying the unequal division. Auxiliary Table N, which was prepared a number of years

AUXILIARY TABLE N

PERCENTAGE OF STORM WINDS FROM EACH DIRECTION FOR CERTAIN STATIONS ON THE UPPER LAKES, FROM 1893 TO 1897, INCLUSIVE

(From Cox, *Bulletin No. 24*, United States Weather Bureau, p. 157)

Station	N	NE	E	SE	S	SW	W	NW
Duluth, Minn.	1	30	0	0	0	16	0	53
Marquette, Mich.	4	0	0	11	32	29	4	20
Sault Ste. Marie, Mich.	0	3	2	18	0	6	4	67
Green Bay, Wis.	30	3	0	2	4	24	21	16
Milwaukee, Wis.	6	7	4	12	4	30	21	16
Grand Haven, Mich.	2	1	13	6	7	6	15	50
Chicago, Ill.	6	11	3	13	22	29	10	5
Alpena, Mich.	2	1	9	17	1	17	19	34
Port Huron, Mich.	8	5	2	4	13	33	18	17
Mean	7	7	4	9	9	21	12	31

ago in a study of this phase of the subject, will illustrate the comparative frequency of storm winds from certain directions and the absence of such from others. The verifying velocities at the various stations are arbitrarily fixed, and depend entirely upon the exposure of the anemometer, there being a wide variation between the different limits.

Thus it will be seen that, while for the upper lakes as a whole storm winds are most frequent from southwest to northwest, these directions including 64 per cent of the total number occurring, the figures for Chicago indicate a greater frequency from southeast to southwest, with the same percentage, 64; because, being located at the southern limit of the Lake region, a larger percentage of storm centers pass north of the city than is the case with the other stations in the table, so increasing the frequency of southerly winds. The barometric gradient following in the rear of these southerly storms is relatively not so great at Chicago as in the northern Lake region, and, as a consequence, storm winds from the northwest are less prevalent here. The direction east yields the least number of storm winds for practically all stations, and their small number is in a measure the result of actually lower velocities from this quarter (p. 299). Again, onshore winds are usually of higher velocity than off-shore winds, because of the much less friction offered by the surface of the water, and this tends to increase the frequency of storm winds from the direction of the lake, as is shown in the table by the relatively higher percentages from northeast at Chicago and Duluth, and from northwest at Sault Ste. Marie and Grand Haven, than occur on either side of these directions. A most important factor is the configuration of the country where the station is located, and the topography may be such that from certain directions storm winds never occur. At Duluth, for instance, the obstructions are such to the east, south-east, and south that winds have never reached verifying velocities from these directions; while at Sault Ste. Marie storm winds are confined almost entirely to the direction of the valley of the St. Mary's River, high winds seldom passing across the valley. There is another factor of much importance in some locations, which might be termed artificial: that is, the character of the exposure of the anemometer which indicates the occurrence of storm velocities, with reference to buildings. This factor has already been discussed in detail for Chicago (pp. 282–89) and it remains only to call attention to the fact that lake winds have a much higher velocity as they approach the shore than is the case after being retarded and deflected upward over the numerous structures in their course to the wind register at the Weather Bureau office. For this reason some onshore winds of storm velocity are not recorded as such at the Federal Building, and the records can be harmonized only by reducing the verifying velocities for onshore storms so as to allow for the retardation.

MEAN HOURLY WIND VELOCITY

Table CXXXIII and Fig. 62 show the average hourly velocity of the wind by months from 1890 to 1910, inclusive. The mean velocity for the year is 16.3 miles an hour, ranging from an average of 18.2 miles in March to 13.3 miles in August. The highest wind velocities occur in the spring, because at that time of year the equilibrium of the atmosphere is disturbed most by the rapid changes in temperature accompanying the rise from the winter's cold to the heat of summer. Areas of general disturbance are more frequent at this time, and move rapidly across the country, often accompanied by severe gales. In August, the month of least average velocity, there is but little barometric gradient, and the weather from day to day is more or less settled. Throughout the year the average velocities of the winter months are considerably higher than those of the summer season.

On the average, the highest velocities of the day occur between 2 and 3 P.M., at which time the mean for the year is 17.7 miles; while the period of least wind is that between 6 and 7 A.M., 15.4 miles. It will thus be seen that the day is nearest calm just after the occurrence of minimum temperature, and windiest just before the time of maximum in the afternoon (p. 136). For the year the period of least wind is during the night and early morning in July, while the highest velocities are experienced on the average at about 2 o'clock in the afternoon in the month of April. At the latter time the land temperatures are rising rapidly, causing and maintaining the lake wind from the northeast with its clear sweep for many miles over the smooth surface (p. 142). In both table and graph the effect of change of location is not material, as the values of both the Auditorium Tower and the Federal Building have been combined.

PREVALENCE AND VELOCITY OF WINDS FROM DIFFERENT DIRECTIONS

As previously stated, the observations of wind direction are confined to the eight principal points of the compass, and no record has been made of intermediate directions. During the period of occupancy of the Auditorium Tower the number of miles of movement and the time of the winds from each of these eight directions were recorded, so that it is possible to calculate the relative prevalence and the average velocity of these different winds. The data are given in Table CXXXIV for the years 1891–1904, inclusive. On the average the velocity of the wind varies greatly with its change of direction,

TABLE CXXXIII

MEAN HOURLY WIND VELOCITY, 1890–1910

Month	Hour Ending																								Mean
	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Mdt.	
January........	16.7	16.5	16.3	16.1	16.0	16.1	15.7	16.1	16.5	16.7	17.0	17.8	17.5	17.8	17.8	17.7	17.3	17.5	17.2	17.2	17.2	17.0	17.1	17.3	16.9
February.......	17.3	17.1	17.1	16.9	16.7	17.0	17.0	17.4	17.6	17.9	18.2	18.9	18.9	19.0	19.2	19.1	18.9	18.4	18.2	18.1	18.1	18.0	17.9	17.7	17.9
March..........	17.4	17.4	17.4	17.3	17.3	17.5	17.4	17.7	18.0	18.3	18.4	19.1	19.1	19.5	19.8	19.7	19.4	18.9	17.9	17.8	17.8	17.8	17.5	17.7	18.2
April..........	17.0	17.1	17.2	17.3	17.4	17.4	17.3	17.7	18.2	18.5	18.7	19.4	19.4	20.0	19.8	19.8	19.2	18.6	17.7	17.6	17.4	17.3	17.2	17.3	18.1
May............	15.8	15.8	15.8	16.0	16.0	15.7	15.6	15.9	16.4	17.0	17.4	18.0	18.2	18.4	18.6	18.5	18.1	17.3	16.0	15.5	15.6	15.6	15.6	15.6	16.6
June...........	13.6	13.5	13.2	13.1	13.3	13.3	13.0	13.2	13.5	13.9	14.4	15.0	15.2	15.4	15.7	15.6	15.3	14.6	13.6	12.8	12.8	13.0	12.9	13.3	13.9
July...........	12.6	12.8	12.8	12.8	12.7	12.7	12.3	12.5	13.0	13.4	13.8	14.5	15.0	15.3	15.4	15.3	14.8	14.3	13.1	12.4	12.4	12.5	12.5	12.8	13.4
August.........	13.0	13.0	12.8	12.8	12.6	12.6	12.2	12.2	12.5	12.9	13.4	14.0	14.3	14.8	15.2	15.0	14.7	14.0	13.1	12.9	12.8	12.8	12.9	13.1	13.3
September......	15.6	15.4	15.2	15.2	14.9	14.9	14.6	14.6	14.7	15.1	15.4	16.1	16.3	16.6	16.7	16.4	15.6	14.8	14.2	14.6	15.0	15.6	15.6	15.7	15.4
October........	16.4	16.2	16.1	15.8	15.6	15.8	15.7	15.7	16.0	16.0	16.2	17.0	17.2	17.4	17.4	16.9	15.9	15.6	15.7	16.1	16.4	16.4	16.4	16.4	16.3
November.......	16.8	16.7	16.7	16.7	16.8	17.0	16.8	17.2	17.6	17.8	17.9	18.3	18.3	18.4	18.4	17.9	17.3	17.4	17.1	17.2	17.3	17.4	17.1	17.1	17.4
December.......	17.3	17.3	17.2	17.1	17.0	17.1	17.2	17.3	17.6	17.7	17.9	18.5	18.4	18.6	18.5	18.2	18.1	18.2	18.1	18.4	18.4	18.2	17.9	17.7	17.8
Annual.........	15.9	15.7	15.6	15.6	15.5	15.6	15.4	15.6	16.0	16.3	16.6	17.2	17.3	17.6	17.7	17.5	17.0	16.6	16.0	15.9	15.9	16.0	15.9	16.0	16.3

Table CXXXIII shows the mean wind velocity for each hour of the day and for each month of the year, based upon records from 1890 to 1910, 15½ years at the Auditorium and 5½ years at the Federal Building. The above values are graphically shown in Fig. 62.

influenced as it may be by obstructions, character of the surface passed over, rising or falling temperature, and the translation of the storm center around which the wind tends to blow. The strength and frequency of the higher winds from the southwest and south are due mainly to the last two of these influences (p. 292). The next higher velocities are from the northeast, largely because of the great lake surface which extends in that direction and allows the flow of currents over it with but little friction. Even a southwest wind blowing over the city may in some measure be accelerated by the lake surface. As a portion passes out over the lake and is released from the strong friction of the land with its innumerable structures'

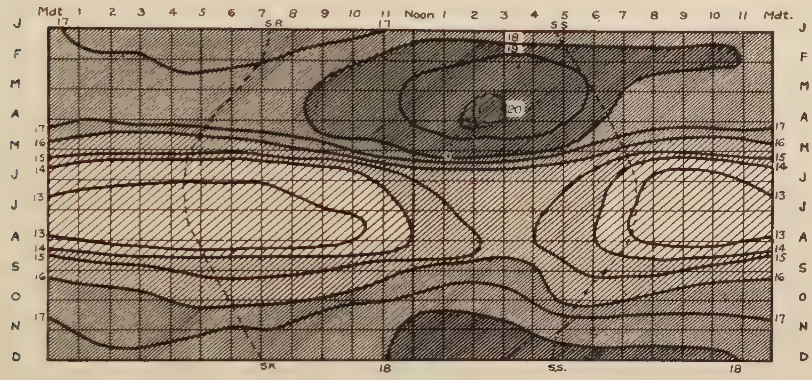


FIG. 62.—Mean hourly wind velocity.

Fig. 62 shows the mean hourly wind velocity for each hour of the day and each month of the year based upon records from 1890 to 1910. The heaviest shading shows the time when the greatest average hourly wind velocity occurs and the lightest shading the time when the average velocity is the least. The dotted lines marked *S.R.* and *S.S.* indicate the varying time of sunrise and sunset during the year (see Table CXXXIII).

it tends to outrun the portions yet over the city, and so diminishes the pressure slightly along the shore, thus increasing the movement over the land.

Due easterly winds at Chicago are much less prevalent than those of any other class, because they usually occur only as shifting currents. This is in turn due to the movements of the great areas of high and low barometric pressure across the Middle States, such rarely approaching or passing directly from the west. Winds from the east, moreover, have the least velocity of any direction, as the cyclonic areas of which they are a part are themselves moving from the west, so that the motion of the latter lessens that of the east wind with reference to stationary objects.

TABLE CXXXIV

AVERAGE NUMBER OF MILES OF WIND AND TIME OF BLOWING FROM EACH DIRECTION, MONTHLY AND ANNUAL, 1891-1904

MONTH	N		NE		E		SE		S		SW		W		NW		Calm	
	Miles	d. h.	Miles	d. h.	Miles	d. h.	Miles	d. h.	Miles	d. h.	Miles	d. h.	Miles	d. h.	Miles	d. h.	Miles	d. h.
January	864	2—10	972	2— 4	577	1—11	970	2— 8	1807	4— 2	2693	5—13	2868	6—16	2454	6— 4	4	0—2
February	932	2— 9	1503	3— 2	640	1—14	1033	2—10	1473	3— 0	2045	3—21	2775	6—11	2127	5— 9	1	0—1
March	1449	3—10	2484	5— 6	1025	2—12	1550	3—11	1861	3—21	2444	4— 9	1695	3—23	1544	3—22	1	0—1
April	1676	3—18	3425	7—11	979	2—13	1547	3—16	1995	4— 0	1838	3—12	1218	2—21	890	2— 9	3	0—2
May	1336	3— 6	3572	7—17	646	2— 1	1338	3—16	1819	4— 6	2372	4—22	1327	3— 7	623	1—18	5	0—2
June	816	2—15	2627	7—14	804	3— 2	1169	3—21	1349	3—14	1983	4—14	1071	2—23	616	1—22	7	0—4
July	776	2— 9	2404	7— 4	638	2—19	1035	3—16	1205	3— 7	2538	5—22	1287	3—16	539	1—20	10	0—6
August	827	2—14	2602	7— 9	906	3— 9	1239	4— 4	1178	3—12	2112	5— 3	924	2—17	599	2— 0	10	0—5
September	888	2—12	1788	4— 7	980	2— 3	1348	3—15	2351	5—10	2633	5—19	1233	3— 8	987	2—17	7	0—5
October	975	2—19	1552	3—21	610	1—20	1386	3— 8	2520	5—13	2774	5—14	1745	4—11	1234	3—11	3	0—2
November	932	2—15	1573	3— 7	270	0—20	877	2— 3	2541	5— 6	2959	5—15	2099	5— 5	1940	5— 7	1	0—1
December	832	2— 5	1060	2— 5	480	1— 1	847	1—21	2719	4—11	3840	7— 4	2700	6—16	2014	5— 9	2	0—3
Annual mean	1025	2—18	2130	5— 3	713	2— 2	1195	3— 4	1902	4— 5	2519	5— 4	1745	4— 8	1297	3—12	4	0—3
Average hourly velocity	15.6		17.3		14.2		15.6		18.9		22.8		16.6		15.4			

Table CXXXIV shows the total number of miles and the length of time in days and hours the wind was observed to blow from the above eight directions for each month from 1891 to 1904; also the length of time there was no wind or a calm prevailed. The average hourly velocity for each direction is also given. These values are graphically represented in Fig. 63. The direction prevailing during this period, southwest, as shown above, is different from that indicated for the same period in Table CXXVIII, as the method of calculation is somewhat different. In Table CXXXIV the averages are determined from the actual number of hours during which the wind blew from each direction. In Table CXXVIII, the prevailing direction of each year is determined from the prevailing direction of the months in that year.

The average hourly velocities for the various directions are: north, 15.6; northeast, 17.3; east, 14.2; southeast, 15.6; south, 18.9; southwest, 22.8; west, 16.6, and northwest, 15.4 miles an hour. Differences of exposure, however, influence the velocities from all directions, as has already been pointed out (pp. 282–89).

The graphic values in Fig. 63 have been drawn from the data in Table CXXXIV. The degree of prevalence of each direction is shown for the months of the year by the length of line, while the average velocity of the direction is indicated by the breadth of line. It is easily to be seen that north winds prevail but little, and east winds least of all. Beginning with January, west and northwest winds diminish, and north and northeast winds increase. The north wind reaches its maximum prevalence in April, but the northeast wind continues to blow for longer periods until May, and remains the prominent wind until the beginning of autumn, when the south-to-west directions assume dominancy. At no time of the year is the north, east, or southeast wind the prevailing direction in the cycle of changes. The little occurrence of the second has already been explained. The other two more or less parallel the shore of the lake, and the lake and land influence tends to divert them either to the one side or the other. Taking the seasons into consideration, the preponderance of westerly winds in winter is scarcely more marked than that of the easterly winds of the summer and spring.

The average times shown for each direction in the table give the best basis for determining the prevailing wind direction during the period covered, and this is shown to be southwest, with an average duration of 5 days 4 hours each month, against 5 days 3 hours each month for the direction northeast, the next most persistent wind. However, as calculated by the method in common use (p. 278)—that is, from the prevailing directions of the various months—the prevailing wind direction of the period in the table under discussion, 1891 to 1904, inclusive, is strongly northeast (see Table CXXVIII). During this time the prevailing direction as calculated was northeast for 60 months, and southwest for only 36 months; while, by an actual count of the hours and minutes each blew, the southwest wind averaged 1 hour longer for each month of the entire period. Such differences in recording the prevailing wind direction are, however, of rare occurrence, and probably only happen when certain wind directions are controlled by strong but non-periodic influences, such as govern the spring and summer lake wind at Chicago (p. 142).

RESULTANT DIRECTION AND MOVEMENT

The prevailing wind direction, based upon the records from 1872–1913, inclusive, has been shown to be southwest (p. 280); that is,

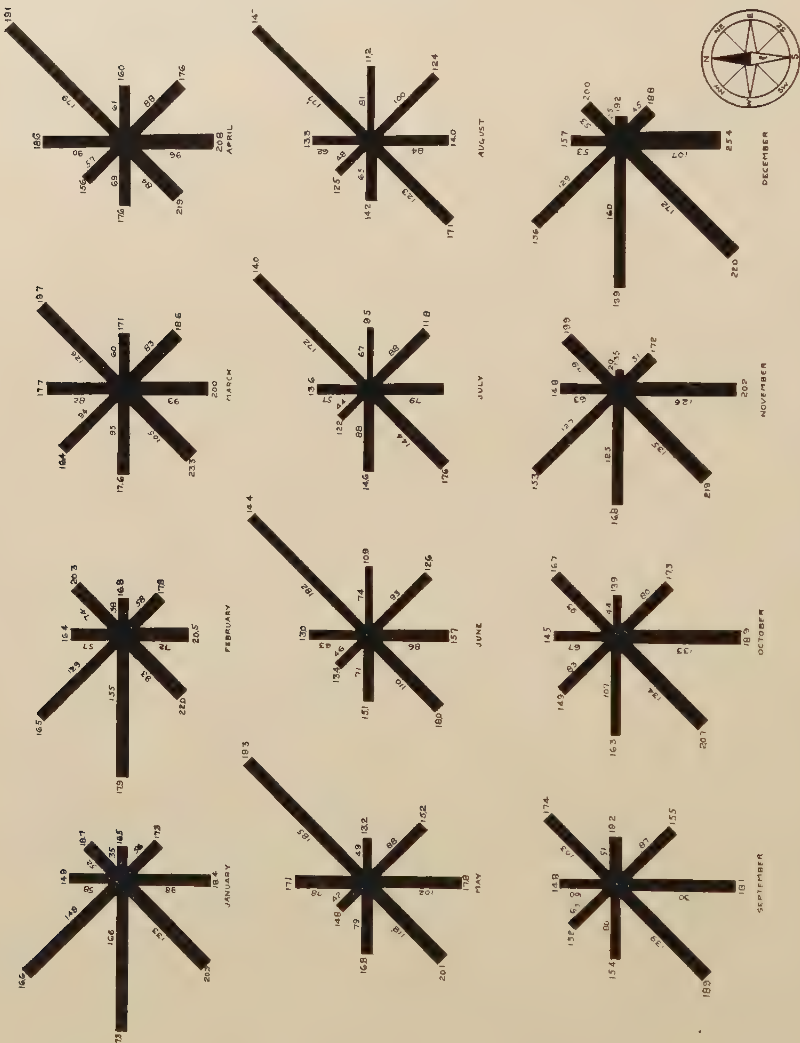


Fig. 63.—Average duration and velocity of wind.

Fig. 63 graphically represents the average duration and velocity of the wind for each direction of the compass for each month of the year, based upon records from 1891 to 1904, covering the greater portion of the record of the Weather Bureau while at the Auditorium. The average hourly velocities are indicated by figures at the end of the columns and the average duration is shown by the figures along the side of the columns. The width and length of the columns are proportional to the velocity and duration of the wind from each direction.

in the aggregate the wind has blown from that direction longer than from any other. The prevailing direction involves the factor of time. Resultant wind direction involves the factor of movement.

For instance, should the wind blow from the north for 20 hours of the day, north would be the prevailing wind direction without regard to its velocity. If this velocity were 5 miles an hour, and during the remaining 4 hours of the day the wind blew from the south at 30 miles an hour, while the prevailing direction would remain north, the resultant direction would be south, and the resultant movement (30×4−5×20) 20 miles.

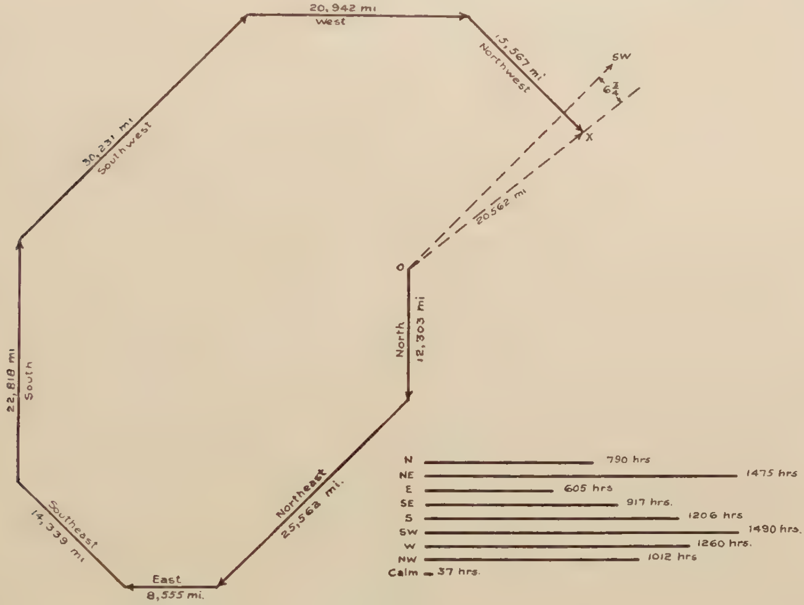


Fig. 64.

Fig. 64 represents the total wind movement from each direction and the resultant wind direction, also the total duration in hours for each direction and for calm, based upon a 15-year period from 1891 to 1904, covering the greater portion of the record of the Weather Bureau while at the Auditorium. The resultant wind direction is represented by *O–X*, with a total number of miles of 20,562. The resultant wind direction is shown to be about 7° south of southwest (see Table CXXXIV).

The resultant direction and movement of the wind for the Auditorium Tower record are shown in Fig. 64. Starting at some point, O, lines proportional to the wind movement are drawn for the successive points of the compass, beginning with north and reaching the end of the final direction at X. OX, which has a value of 20,562 miles, then marks the resultant movement of winds for the entire period; and its direction from O, very nearly 6° 45′ south of southwest-northeast, as shown, is the resultant direction. Theoretically, a

body of air at O would in the course of a year pass through the changes indicated in the polygon, arriving at X, 20,562 miles distant, in a line extending 6° 45′ south of northeast.

The lines in the lower right-hand corner of the figure show the relative duration of the wind from each direction during the course of an average year. Here again it is to be noted that southwest has the greatest value, 1,490 hours, although northeast is a close second with 1,475 hours. Comparing these values, however with those of the movements of the two directions indicates that the average velocity of the southwest wind is considerably the greater.

PREVAILING HOURLY WIND DIRECTION

Table CXXXV and Fig. 65 show the prevailing wind direction hour by hour for the various months of the year from 1892 to 1910, inclusive. The preponderance of northeast winds throughout the late morning, afternoon, and much of the evening of the spring and summer months is apparent at a glance. During the month of April the northeast wind prevails for every hour of the day. As the water of the lake gradually warms, however, the frequency of such winds diminishes until October, when the temperature of the lake is approximately that of the air. In the ensuing months, from November to February, the prevailing hourly direction is altogether from a westerly direction. There is no prevailing hourly direction indicated for north, east, or southeast. All other directions prevail at some time or other, but the most frequent are southwest and northeast. Out of the total of 288 hourly entries in the table, the northeast direction appears 106 times, with southwest, south, west, and northwest distributed unequally among the remaining hours. Calculated upon a basis of hourly frequency, the northeast wind is shown to be the prevailing wind, rather than the southwest wind, as indicated in Table CXXXIV, but it must be remembered that the two are of nearly equal frequency, and the tables in question are for somewhat different periods (see also p. 301).

Table CXXXVI and Fig. 66 show the prevailing hourly wind direction for Davenport, Iowa, of nearly the same latitude as Chicago, for the period covered by the data for Chicago in the previous table and graph. By hours, the prevailing direction for the year at Davenport is southwest, whereas northeast winds were most frequent at Chicago during the period 1892–1910, inclusive. There are only three hours at the inland city when the prevailing direction is northeast,

TABLE CXXXV

PREVAILING HOURLY WIND DIRECTION, CHICAGO, ILL., 1892–1910

Month	Mdt. to 1 A.M.	1 A.M. to 2 A.M.	2 A.M. to 3 A.M.	3 A.M. to 4 A.M.	4 A.M. to 5 A.M.	5 A.M. to 6 A.M.	6 A.M. to 7 A.M.	7 A.M. to 8 A.M.	8 A.M. to 9 A.M.	9 A.M. to 10 A.M.	10 A.M. to 11 A.M.	11 A.M. to Noon	Noon to 1 P.M.	1 P.M. to 2 P.M.	2 P.M. to 3 P.M.	3 P.M. to 4 P.M.	4 P.M. to 5 P.M.	5 P.M. to 6 P.M.	6 P.M. to 7 P.M.	7 P.M. to 8 P.M.	8 P.M. to 9 P.M.	9 P.M. to 10 P.M.	10 P.M. to 11 P.M.	11 P.M. to Mdt.	Prevailing Direction
January	NW	W	NW	NW	NW	NW	NW	NW	NW	NW	SW	W	SW	SW	W	W	W	W	NW	NW	NW	NW	NW	NW	NW
February	W	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	SW	W	W	W	W	W	W	W	W	W	W	W	W	W
March	SW	SW	SW	SW	SW	SW	NW	NW	SW	SW	SW	NE	SW	NE	NE	NE	NE	NE	NE	NE	NE	SW	SW	NE	SW
April	NE	NE	SW	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	SE	NE	NE	NE	NE
May	SW	SW	SW	SW	SW	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
June	SW	SW	SW	SW	SW	SW	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	S	NE	NE
July	SW	SW	SW	SW	SW	SW	SW	SW	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	SW	SW	SW	NE
August	SW	SW	SW	SW	SW	SW	SW	SW	SW	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	SW	NE
September	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	NE	NE	NE	NE	NE	NE	S	S	S	S	S	SW	SW
October	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	NE	NE	S	S	S	S	S	S	SW	SW
November	NW	NW	NW	NW	SW	W	NW	S	SW	SW	SW	SW	W	W	W	W	W	W	W	W	W	NW	NW	NW	W
December	W	NW	W	W	SW	W	W	W	SW	W	W	SW	W	W	W	W	SW	W	W	W	W	W	SW	SW	W
Annual	SW	SW	SW	SW	SW	SW	NW	SW	SW	NE	SW	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	S	SW	NE

Table CXXXV shows the prevailing direction of wind by hours and months based upon records from 1892 to 1910. These values are graphically represented in Fig. 65. The prevailing direction for the period, northeast, differs from that of the total period of official record, southwest, as shown in Table CXXVIII, which covers 20 years not included in the table above.

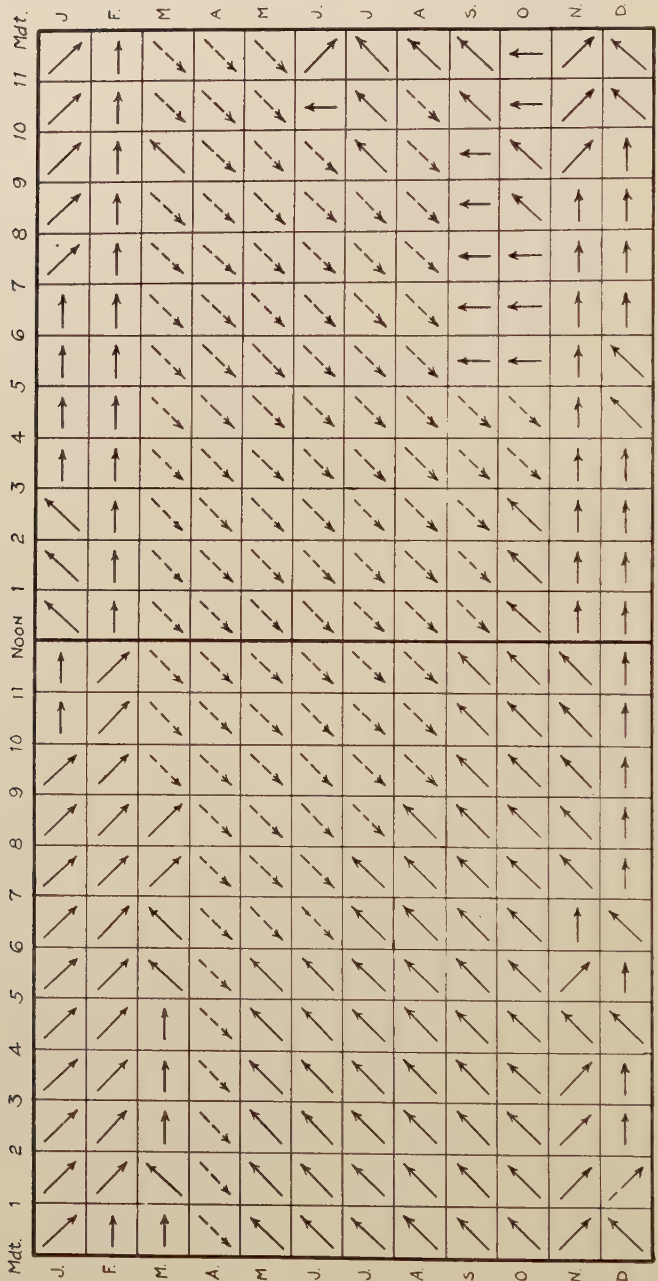


FIG. 65.—Prevailing hourly wind direction, Chicago.

Fig. 65 shows the prevailing hourly wind direction by months based upon records from 1892 to 1910, contained in Table CXXXV (see also note to Table CXXXV).

TABLE CXXXVI

PREVAILING HOURLY WIND DIRECTION, DAVENPORT, IOWA, 1892–1910

Month	Mdt. to 1 A.M.	1 A.M. to 2 A.M.	2 A.M. to 3 A.M.	3 A.M. to 4 A.M.	4 A.M. to 5 A.M.	5 A.M. to 6 A.M.	6 A.M. to 7 A.M.	7 A.M. to 8 A.M.	8 A.M. to 9 A.M.	9 A.M. to 10 A.M.	10 A.M. to 11 A.M.	11 A.M. to Noon
January	NW	NW	W	NW	NW	NW	NW	NW	NW	W	W	W
February	W	W	W	NW	NW	NW	W	W	W	SW	NW	NW
March	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW
April	E	E	E	E	E	E	E	E	NW	NW	NW	NW
May	E	E	E	NE	E	E	NE	NE	SW	SW	E	SW
June	E	E	E	E	E	E	E	E	E	E	SW	SW
July	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
August	E	SW	SW	SW	E	E	E	E	SW	SW	SW	SW
September	SW	SW	S	SW	SW	S	SW	SW	SW	SW	SW	SW
October	SW	NW	SW	SW	NW	SW	SW	E	SW	SW	SW	SW
November	NW	W	NW	NW	NW	NW	W	NW	NW	NW	NW	NW
December	W	SW	SW	W	W	W	W	W	W	W	SW	SW
Annual	E	SW	SW	NW	NW	NW	W	E	SW	SW	SW	SW

Month	Noon to 1 P.M.	1 P.M. to 2 P.M.	2 P.M. to 3 P.M.	3 P.M. to 4 P.M.	4 P.M. to 5 P.M.	5 P.M. to 6 P.M.	6 P.M. to 7 P.M.	7 P.M. to 8 P.M.	8 P.M. to 9 P.M.	9 P.M. to 10 P.M.	10 P.M. to 11 P.M.	11 P.M. to Mdt.	Prevailing Direction
January	SW	SW	NW	NW	NW	NW	NW	W	NW	NW	NW	NW	NW
February	NW	NW	W	W	W	W	W	W	W	NW	W	W	W
March	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW
April	SW	NW	NW	NW	NW	NW	NW	NW	NW	E	NW	NW	NW
May	SW	SW	SW	SW	SW	SW	SW	E	E	E	E	E	SW
June	SW	SW	SW	SW	SW	SW	SW	SW	E	E	E	E	E
July	SW	SW	SW	SW	SW	SW	SW	SW	SW	E	SW	SW	SW
August	SW	SW	SW	SW	SW	SW	SW	SW	E	E	E	SW	SW
September	SW	SW	SW	SW	SW	SW	S	E	E	E	E	SW	SW
October	NW	SW	NW	NW	SE	W	NW	NW	NW	NW	W	SW	SW
November	NW	SW	SW	NW	NW	W	W	W	NW	W	NW	NW	NW
December	SW	SW	SW	W	W	W	W	W	W	W	W	W	W
Annual	SW	SW	SW	SW	SW	SW	NW	W	NW	E	E	SW	SW

Table CXXXVI shows the prevailing direction of wind by hours and months based upon records from 1892 to 1910. These values are graphically represented in Fig. 66.

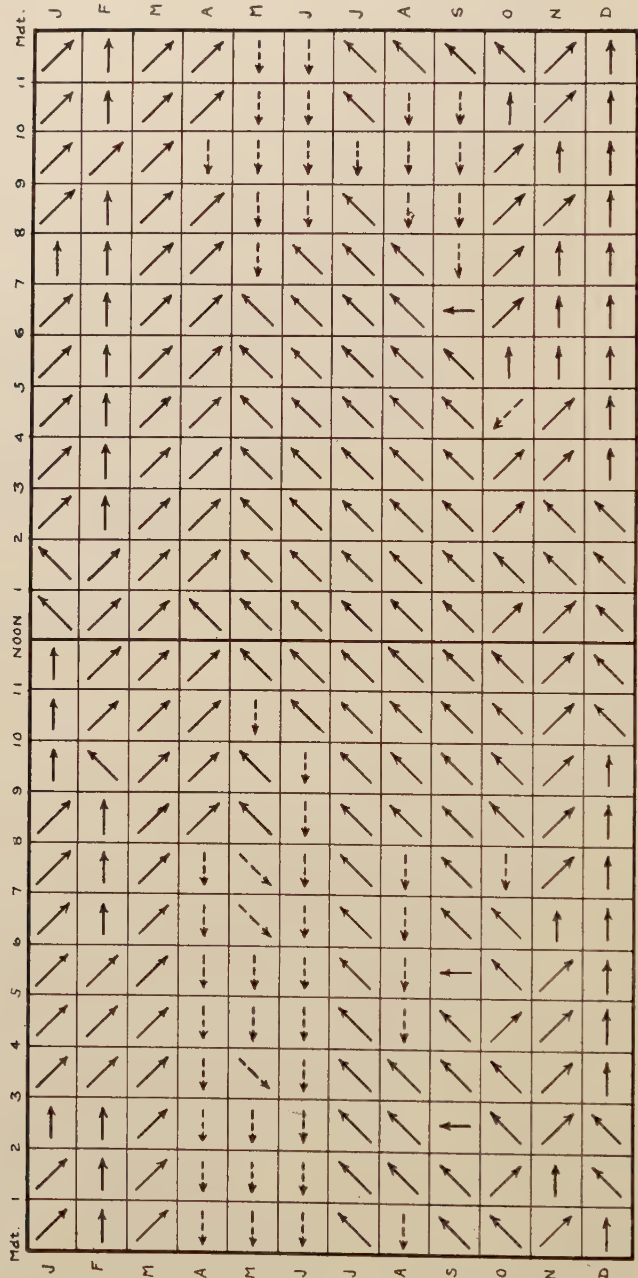


FIG. 66.—Prevailing hourly wind direction, Davenport, Iowa.

Fig. 66 shows the prevailing hourly wind direction by months at Davenport, Iowa, based upon records from 1892 to 1910, contained in Table CXXXVI.

but there are several hours of prevailing easterly winds during the night and early morning. These instances are doubtless due to local causes, which it is impracticable to present in detail. While there is much difference between the prevailing wind directions of the two places during the spring and summer months, which serves to emphasize the influence of the lake at Chicago in determining its wind direction at that time, there is considerable uniformity during the winter, especially in the months of January and February. The prevalence of the northeast wind at Chicago is responsible for its low maximum temperatures and comparatively cool weather during the warm season (p. 37). With a normal summer temperature, such as prevailed in Chicago during the summer of 1910, there were only 9 days on which 90° was reached or exceeded, while at Davenport there were 28 such days, the lake wind being the cause of their infrequent occurrence in the larger city.

COMPARISON OF WIND VELOCITY AT CHICAGO WITH THAT AT OTHER CITIES OF THE UNITED STATES

While comparisons have been made in the previous pages between the values of temperature, precipitation, sunshine, and humidity for Chicago and other portions of the United States, as represented by selected cities, it is much more difficult to present properly the relative wind velocities of those places. The exposure of the anemometer, as has already been shown (p. 296), influences the record of wind movement to such a degree that it is almost an impossibility to secure comparable records in any one of the larger cities.

The data for 1909, a typical year, on wind velocity for the various places used in former comparisons, however, are presented for what they may be worth, in Table CXXXVII and Fig. 67. Other things being equal, wind velocity increases with elevation, and the highest velocities occur in the regions lying in the paths of the most frequent storms. Chicago, being in the path of the southwest disturbances which cause our heaviest northeast winds, and on the southern side of those whose centers pass over the northern Lake region, has doubtless as high a wind velocity as have the majority of northern cities. Wind velocity, on the average, is considerably lower in the southern sections of the country, because there the changes in weather and temperature are not so abrupt, and the reason that this relation is not apparent in the table is doubtless due to differences in exposure of the anemometers as regards elevation,

configuration of the country, and surrounding buildings. If it were possible to secure similar exposures for all of the lake cities, we should probably find that the wind velocity does not differ much from place to place, when average conditions are compared. Of the cities shown in the table, Chicago leads in average wind velocity for the year, with 14.4 miles an hour, and New York is second with 13.0 miles; while the cities showing the lowest velocities are Portland, Ore., and Yuma, Ariz., with 6.5 miles each.

TABLE CXXXVII

Average Hourly Wind Velocity by Months for 15 Selected Cities for the Year 1909

(See Fig. 67)

Station	Anemometer above Ground Feet	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Portland, Ore......	106	7.7	8.1	6.2	6.0	6.1	6.3	5.9	6.2	5.5	5.3	7.8	7.1	6.5
San Francisco, Cal..	204	10.1	7.8	7.4	8.3	11.1	12.2	11.7	11.5	8.3	6.5	5.4	6.1	8.9
Yuma, Ariz........	58	5.7	7.1	7.5	8.2	7.2	6.4	6.6	5.6	4.7	4.8	6.1	7.9	6.5
Havre, Mont.......	44	9.0	8.3	7.8	9.1	10.7	7.5	7.6	6.3	7.1	7.5	8.9	9.9	8.3
Denver, Colo.......	136	7.2	8.5	7.4	8.2	7.8	6.5	6.2	6.1	6.2	7.1	7.1	5.9	7.0
El Paso, Tex.......	133	10.2	13.2	14.2	15.0	14.6	10.4	10.8	10.5	10.6	9.2	10.4	11.8	11.7
Moorhead, Minn...	57	10.5	8.7	9.5	11.0	9.5	6.7	6.7	6.7	7.6	10.1	10.0	8.9	8.8
Omaha, Neb.......	121	10.6	10.4	10.5	12.2	9.2	7.0	6.4	6.6	6.2	8.6	9.4	9.5	8.9
Galveston, Tex....	112	11.0	13.3	11.0	12.9	12.5	10.5	11.0	10.2	10.1	10.4	12.3	13.7	11.6
Marquette, Mich...	116	13.7	10.9	9.3	10.7	8.8	7.2	9.3	9.0	9.7	11.2	12.3	11.0	10.3
Chicago, Ill........	310	13.4	17.3	14.6	17.4	15.7	11.1	11.8	10.7	12.1	14.7	17.3	16.5	14.4
New Orleans, La...	121	8.3	11.1	10.8	10.8	9.2	7.0	7.2	7.4	7.9	7.2	7.5	9.9	8.7
Northfield, Vt.....	70	10.3	9.0	8.2	10.6	9.3	7.6	8.0	6.7	7.6	7.5	9.0	7.0	8.4
New York, N.Y....	350	13.8	16.4	16.6	14.5	12.3	9.7	10.6	10.2	10.2	12.6	12.8	16.1	13.0
Jacksonville, Fla...	129	8.8	9.8	10.9	9.8	8.4	9.1	9.2	7.6	8.4	8.4	8.4	9.2	9.0

The maximum velocities for each month of the year 1909, recorded at the cities included in the previous table, are given in Table CXXXVIII. While the highest velocity at Chicago during that year was 60 miles an hour, several cities experienced more severe winds: El Paso, Tex., 67 miles; Omaha, Neb., 66 miles; Galveston, Tex., 68 miles; New Orleans, La., 66 miles, and New York City, 83 miles.

COMPARISON OF WIND VELOCITY WITH OTHER CONDITIONS

Following the discussion of temperature, precipitation, sunshine, and wind velocity, it will be interesting to compare the monthly values of these elements together. Fig. 68 illustrates in four curves these monthly mean values in successive order. The curves that

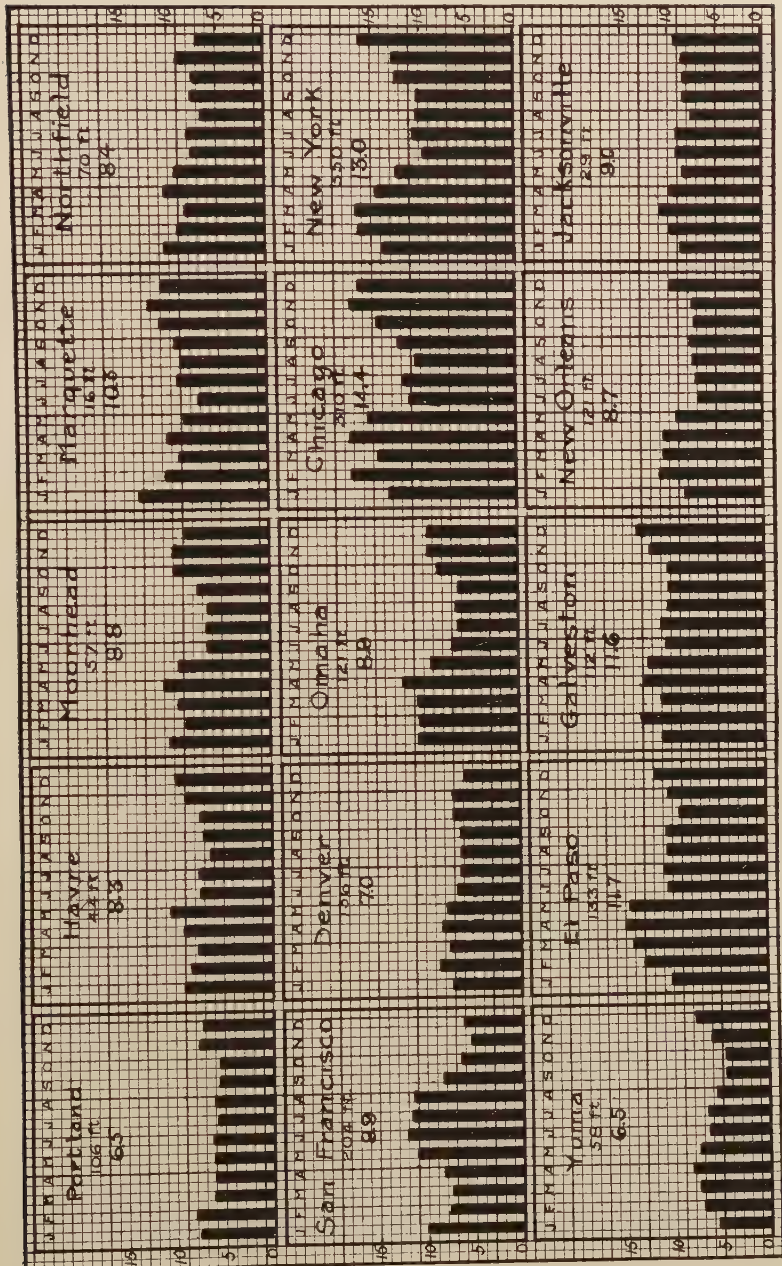


FIG. 67.—Mean hourly wind velocity in miles.

Upper line of figures=height of anemometer in feet above ground; lower line of figures=mean hourly velocity for 1909.

show the closest relation are, of course, those of temperature and sunshine, and while the line of precipitation gives an increase in the warm period, the changes are not at all regular. Still, the influence of the enlarged capacity of the atmosphere for carrying moisture when temperatures are high is easily detected. In general the velocity of the wind decreases as the values of the other three elements increase. The influence of sunshine and high temperature is to increase wind velocity (p. 292), and the lower velocities of summer must therefore be accounted for by the fact that active and general storm areas are much less frequent in that season, and high winds are in many cases due to brief squalls.

TABLE CXXXVIII

Monthly Maximum Wind Velocities for 15 Selected Cities for the Year 1909

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Portland, Ore.	36	32	32	25	24	25	18	26	24	24	39	33	39
San Francisco, Cal.	48	34	34	32	33	36	34	34	36	29	28	33	48
Yuma, Ariz.	29	36	37	37	26	23	28	27	32	28	30	32	37
Havre, Mont.	36	36	35	34	42	39	36	46	38	36	46	43	46
Denver, Colo.	45	38	36	44	37	31	33	28	30	34	35	32	45
El Paso, Tex.	43	58	60	60	50	54	67	40	38	54	43	49	67
Moorhead, Minn.	44	30	30	38	36	30	24	28	27	32	39	30	44
Omaha, Neb.	66	39	37	48	38	27	38	23	35	33	30	32	66
Galveston, Tex.	50	44	53	46	60	40	68	33	34	54	30	46	68
Marquette, Mich.	46	47	33	54	29	30	40	40	36	36	40	32	54
Chicago, Ill.	48	48	38	60	50	48	42	32	36	46	48	52	60
New Orleans, La.	37	45	37	37	30	28	30	36	66	27	28	27	66
Northfield, Vt.	41	36	31	42	37	30	36	36	29	31	36	33	42
New York, N.Y.	57	73	60	83	48	43	46	40	45	46	48	58	83
Jacksonville, Fla.	56	49	39	29	40	42	55	46	27	27	27	42	56

Fig. 69 indicates the influence of temperature upon wind velocity. Here the average hourly temperatures and the average hourly wind velocities are given for the period 1890 to 1910, inclusive, and the relation is seen to be direct. The lowest point in the temperature curve is at 6 A.M., and that in the velocity curve at about 6:40 A.M., while the peaks of both curves are reached at 3 P.M. After the maximum values are attained there is a steady decrease until evening, the temperature continuing the decrease until the time of minimum the following morning, when the cycle is begun over again. The wind velocity, on the whole, does not change much during the night, but there is, nevertheless, a downward tendency. The increase in wind velocity from minimum to maximum is due to the circulation of the lower strata of the atmosphere as a result of ascensional currents caused by the increase in temperature of the ground under the

influence of insolation. The relation between the two elements, as illustrated, exists at all seasons of the year.

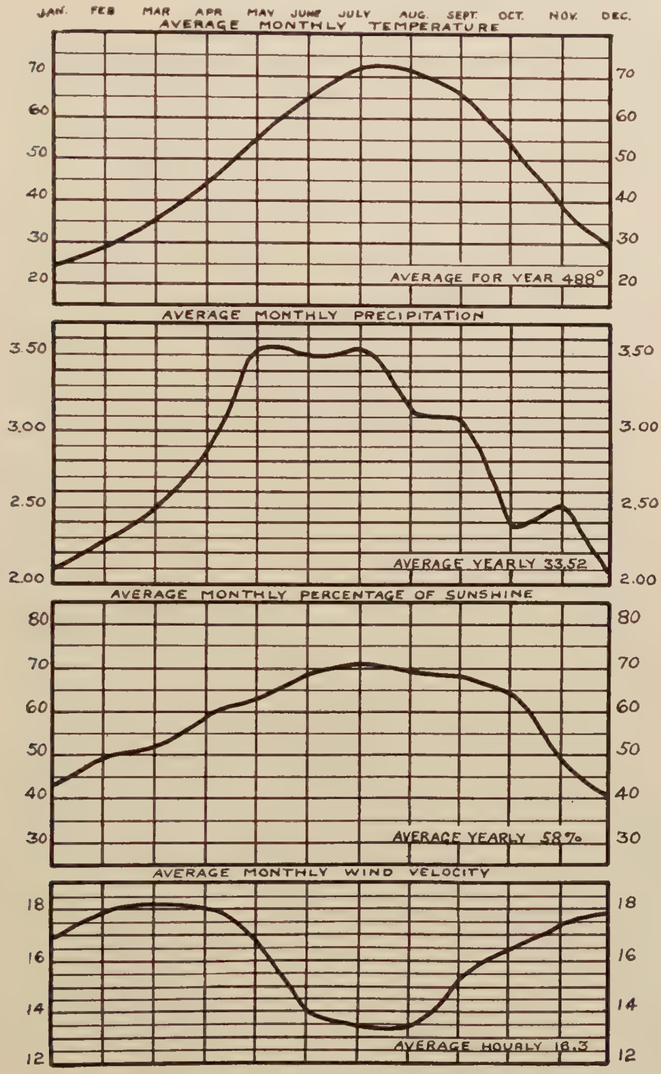


Fig. 68.—Average monthly values.

Fig. 68 contains graphs showing the average monthly temperature, average monthly precipitation, average monthly percentage of possible sunshine, and average monthly wind velocity, based upon all available records, the temperature and precipitation being for the same period, but the sunshine and wind for shorter periods.

SUMMARY OF WIND DATA

Table CXXXIX gives for reference a summary of the principal features relative to the average and extreme values of wind direction and velocity.

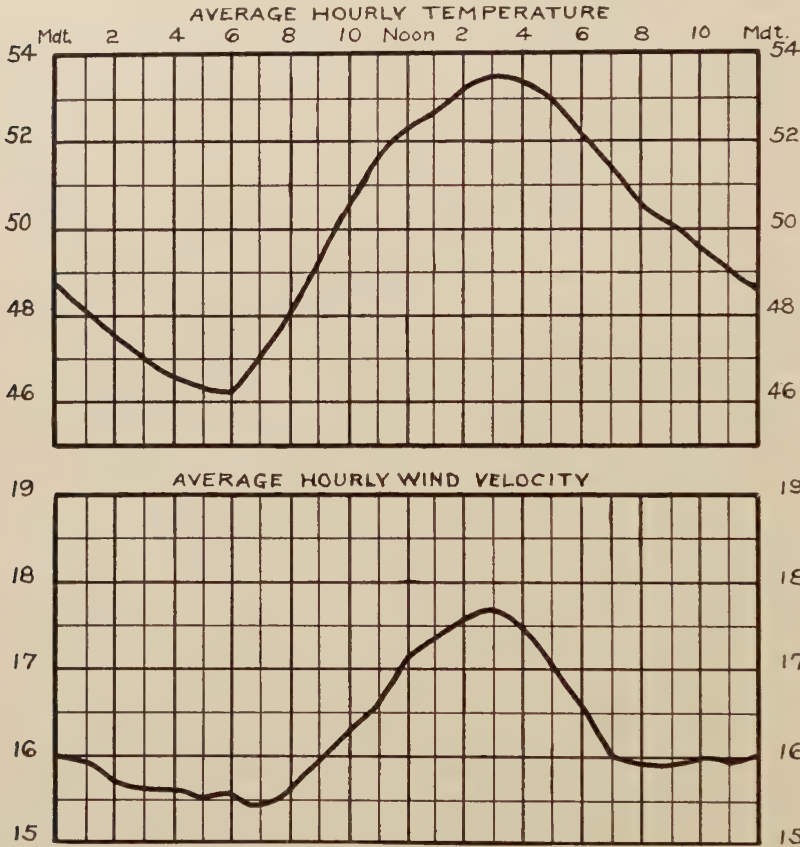


FIG. 69.—Average hourly values.

Fig. 69 contains graphs showing the average hourly values of temperature and wind based upon records from 1890 to 1910.

TORNADOES

Tornadoes, commonly misnamed cyclones, are very severe local storms, developing usually in the southeast quadrants of general storm areas. They occur most frequently in the Great Plains states, and but seldom in the Lake region. These storms are attendant

upon severe thunderstorm conditions, and their energy may be likened to that of a great disturbance compressed into a very small area. The width of the tornado path seldom exceeds a mile, and it is often not more than a few hundred yards. Generally, the narrower the path of the tornado, the greater is its energy. A notable exception to this rule was the severe tornado which occurred at St. Louis, Mo., in May, 1896, with a path of destruction more than a mile across. Chicago and its vicinity, due in a large measure to the

TABLE CXXXIX

SUMMARY OF WIND VELOCITY AND DIRECTION DATA

Month	Means					Maxima					Storm Winds		
	Mean	Highest	Year	Lowest	Year	Mean Maximum	Highest	Year	Lowest	Year	Average Number	Maximum Number	Year
January......	17.2	19.6	1899	13.4	1909	53	66	1898	44	{1896 1908}	4.2	7	1898
February.....	18.0	20.9	1894	14.8	1907	54	84	1894	47	1905	4.6	8	1896*
March.......	18.2	22.2	1894	14.6	1909	54	68	1890	38	1909	6.5	13	1894
April........	18.0	23.9	1893	13.5	1894	55	72	1893	40	{1895 1906 1910}	6.6	14	1893
May.........	16.6	18.8	1893	13.5	1910	53	72	1903	40	1907	4.9	11	1894
June.........	13.9	16.1	1899	10.6	1910	48	72	1892	35	1903	2.6	8	1901
July.........	13.4	15.5	1890	10.7	1906	48	72	1897	36	1896	2.5	6	1895†
August.......	13.3	15.2	1893	10.7	1909	47	72	1898	32	1909	1.8	4	1897†
September....	15.4	18.9	1893	10.6	1910	46	72	1900	35	1910	2.6	7	1895
October......	16.3	18.8	1893	11.2	1910	51	63	1898	36	1908	3.8	8	1902
November....	17.4	21.2	1898	13.0	1910	53	76	1898	39	1910	5.6	10	1898
December	17.8	22.0	1893	14.6	1910	52	72	1904	37	1910	4.6	11	1893‡
Year.........	16.3	23.9	April 1893	10.6	June Sept. 1910	51	84	1894	32	1909	51.8	79	1893

* Also 1908.

† Also 1900.

‡ Also 1904.

Table CXXXIX contains a summary of the more important wind velocity data based upon records from February 1, 1890, to February 1, 1910.

counteracting influence of Lake Michigan (p. 209), have been particularly free from the occurrence of these remarkable and destructive phenomena. As far as known, but two tornadoes have ever occurred within the limits of Cook County, and only the first of these entered the city of Chicago. This tornado occurred two days before the St. Louis tornado, May 25, 1896, passing through that portion of the city known as Norwood Park; the second tornado referred to occurred on April 6, 1912. A thorough study of the former was made immediately after its occurrence, and its path is shown in Fig. 70.

This tornado occurred between 1 and 2 A.M., and at about the same time two other tornadoes occurred in northern Illinois and one in Iowa, while a fourth was reported in the southeastern portion of the lower peninsula of Michigan on the following afternoon. All were formed in the southeast quadrant of a storm or cyclone moving east from Manitoba with a trough of low barometric pressure extending thence southward. General thunderstorm conditions at the time prevailed over the western Lake region and the Middle West; and in the vicinity of the Weather Bureau office in Chicago there was an exceptionally severe thunderstorm, with vivid lightning, heavy squalls of wind, and excessive rainfall. The fall of rain from 2:08

FIG. 70.

ig. 70 shows the path of a tornado which passed through Cook County, Ill., on May 25, 1896. The small arrows along the track indicate in what direction fallen trees lay after the passage of the storm.

to 2:23 A.M. at the station amounted almost to a cloudburst, there being 1.24 inches in the 15 minutes. The highest wind velocity recorded at the station was 62 miles an hour at 1:50 A.M.

The tornado first appeared over the Des Plaines River, close to the boundary line separating the towns of Maine and Leyden in the northern part of Cook County. Generally, the track of the storm lay in an easterly direction, and the disturbance was most destructive in the section called Canfield-on-the-Hill, a portion of Edison Park, and the highest portion of the county, being 125 feet above the lake. The tornado moved thence southeastward, but turned slightly northeastward after reaching Norwood Park,

thence moving eastward, skirting the dividing line between Niles and Jefferson. The path of the storm was clearly cut for over four and a half miles between the Des Plaines and the Chicago rivers, with a width varying from one-fourth to three-fourths of a mile. After reaching the Chicago River the track widened, indicating a decrease in energy, and by the time the tornado arrived at North Fortieth Avenue it had practically lost its identity. The sections over which the disturbance moved were for the most part but sparsely settled, and yet destruction was very great. Six houses were leveled to the ground, and about thirty others so badly damaged as to be almost beyond repair, and the total loss of property amounted to more than $100,000.—Cox, *Bulletin No. 3*, Geographic Society of Chicago.

PART VI

BAROMETRIC PRESSURE

BAROMETRIC PRESSURE

At any moderate elevation above sea level the pressure of the atmosphere is not a direct factor in either weather or climate, in so far as it affects the comfort and health of the individual. No extended space will therefore be devoted to a discussion of the subject, but the main features will be presented as briefly as practicable. Barometer readings are essential to the forecaster of weather conditions, and were observations of all other weather elements omitted it would still be possible to anticipate many changes of conditions from the barometric pressures alone. As far as the ordinary changes in pressure are concerned, however, they do not in the slightest degree affect the sensations of the person in health. Rheumatics, indeed, may often feel twinges when the barometer falls sharply, or drops considerably below the normal, because of the relatively higher pressure within the body; and such persons can sometimes foretell the coming of rains and snows, because precipitation occurs frequently after a falling barometer.

The normal atmospheric pressure at the level of the sea is about 14.7 pounds to the square inch, but the pressure is usually measured in heights of a column of mercury which will exactly equal the pressure of the air. The normal pressure at sea level then becomes 30 inches, and this is sometimes termed the pressure of 1 atmosphere. Pressure diminishes with altitude above sea level, for short distances at the rate of about .001 inch for each foot difference. In determining the average or normal pressure for any location, therefore, it is necessary to take into account the altitude, and any changes in the position of the barometer must be carefully allowed for. The level of Lake Michigan, on the shore of which Chicago is situated, is approximately 581 feet above sea level, but there is some variation in the altitude of some portions of the city above the surface of the lake. The records of the Weather Bureau with reference to air pressure, however, have all been reduced to the elevation of the station above sea level on January 1, 1900, so that the readings presented herein are comparable, notwithstanding the changes in the location of the office since its establishment in 1870. The station elevation is 823 feet above sea level, and is approximately 223 feet

above the average street level of the city. Therefore, when data for street level are desired, the Weather Bureau records of station air pressure should in each instance be increased by about .24 inch.

TABLE CXL

MEAN MONTHLY AND ANNUAL STATION BAROMETRIC PRESSURE, 1873–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Departure in Thousandths
1873	1.123	1.152	1.146	1.028	1.072	1.110	1.150	1.150	1.114	1.127	1.075	1.197	1.120	−12
1874	1.237	1.197	1.155	1.183	1.105	1.087	1.106	1.124	1.146	1.212	1.185	1.208	1.162	+30
1875	1.300	1.185	1.098	1.089	1.055	1.086	1.104	1.094	1.152	1.091	1.168	1.016	1.120	−12
1876	1.170	1.166	1.101	1.085	1.091	0.998	1.109	1.145	1.113	1.050	1.090	1.178	1.108	−24
1877	1.218	1.264	1.131	1.060	1.130	1.026	1.083	1.081	1.130	1.098	1.134	1.186	1.128	− 4
1878	1.135	1.042	1.029	0.894	1.041	1.048	1.095	1.018	1.149	1.098	1.123	1.143	1.068	−64
1879	1.201	1.176	1.164	1.106	1.135	1.101	1.076	1.088	1.188	1.225	1.162	1.168	1.149	+17
1880	1.115	1.136	1.169	1.034	1.089	1.068	1.095	1.130	1.153	1.158	1.260	1.186	1.133	+ 1
1881	1.214	1.190	0.975	1.108	1.127	1.036	1.127	1.132	1.060	1.176	1.161	1.192	1.125	− 7
1882	1.213	1.118	1.136	1.130	1.086	0.997	1.128	1.099	1.188	1.122	1.230	1.176	1.135	+ 3
1883	1.210	1.331	1.233	1.046	1.038	1.025	1.096	1.178	1.178	1.204	1.171	1.171	1.157	+25
1884	1.233	1.116	1.114	1.046	1.044	1.144	1.029	1.140	1.123	1.214	1.174	1.182	1.130	− 2
1885	1.205	1.085	1.156	1.109	1.023	1.123	1.075	1.089	1.139	1.085	1.067	1.133	1.107	−25
1886	1.136	1.154	1.059	1.147	1.067	1.084	1.089	1.086	1.152	1.275	1.108	1.249	1.134	+ 2
1887	1.052	1.218	1.171	1.050	1.089	1.091	1.083	1.116	1.183	1.157	1.156	1.151	1.126	− 6
1888	1.317	1.152	1.208	1.247	1.032	1.044	1.149	1.154	1.179	1.078	1.232	1.168	1.163	+31
1889	1.091	1.215	1.110	1.119	1.065	1.091	1.096	1.190	1.131	1.241	1.168	1.154	1.139	+ 7
1890	1.231	1.146	1.166	1.197	1.027	1.093	1.131	1.178	1.214	1.045	1.154	1.181	1.147	+15
1891	1.139	1.094	1.121	1.110	1.215	1.056	1.143	1.110	1.233	1.207	1.152	1.128	1.142	+10
1892	1.179	1.183	1.156	1.139	1.007	1.041	1.186	1.136	1.197	1.166	1.152	1.181	1.144	+12
1893	1.059	1.176	1.096	0.991	1.017	1.085	1.100	1.134	1.107	1.109	1.118	1.159	1.096	−36
1894	1.150	1.187	1.090	1.103	1.058	1.112	1.143	1.157	1.150	1.038	1.154	1.173	1.126	− 6
1895	1.081	1.200	1.119	1.108	1.114	1.156	1.123	1.065	1.120	1.162	1.191	1.079	1.126	− 6
1896	1.216	1.030	1.147	1.129	1.056	1.098	1.135	1.146	1.138	1.158	1.109	1.252	1.142	+10
1897	1.183	1.147	1.116	1.150	1.124	1.086	1.065	1.115	1.272	1.180	1.161	1.153	1.146	+14
1898	1.098	1.160	1.183	1.166	1.062	1.111	1.157	1.103	1.134	1.113	1.129	1.145	1.130	− 2
1899	1.181	1.143	1.059	1.129	1.133	1.162	1.114	1.112	1.187	1.237	1.160	1.143	1.147	+15
1900	1.151	1.102	1.152	1.154	1.089	1.087	1.098	1.152	1.183	1.207	1.174	1.160	1.142	+10
1901	1.133	1.163	0.940	1.215	1.013	1.073	1.096	1.143	1.161	1.226	1.236	1.145	1.129	− 3
1902	1.241	1.105	1.079	1.075	1.130	1.051	1.118	1.126	1.107	1.151	1.129	1.175	1.124	− 8
1903	1.060	1.179	1.251	1.032	1.159	1.097	1.120	1.112	1.203	1.210	1.204	1.145	1.148	+16
1904	1.171	1.271	1.106	1.147	1.075	1.123	1.136	1.184	1.193	1.192	1.172	1.119	1.157	+25
1905	1.307	1.299	1.164	1.037	1.061	1.092	1.062	1.108	1.151	1.205	1.142	1.179	1.151	+19
1906	1.127	1.325	1.208	1.151	1.092	1.030	1.104	1.117	1.185	1.137	1.244	1.244	1.164	+32
1907	1.266	1.215	1.140	1.093	1.104	1.047	1.064	1.148	1.115	1.221	1.174	1.095	1.140	+ 8
1908	1.111	1.153	1.138	1.045	0.993	1.148	1.180	1.151	1.195	1.233	1.126	1.147	1.135	+ 3
1909	1.231	1.016	1.034	1.059	1.029	1.122	1.108	1.168	1.230	1.187	1.218	1.089	1.124	− 8
1910	1.173	1.236	1.168	1.009	1.139	1.128	1.068	1.131	1.194	1.128	1.105	1.196	1.140	+ 8
1911	1.222	1.222	1.141	1.189	1.148	1.086	1.130	1.152	1.175	1.178	1.105	1.204	1.163	+31
1912*	1.189	1.119	1.260	1.079	1.035	1.170	1.146	1.077	1.151	1.179	1.146	1.079	1.136	+ 4
1913*	1.134	1.165	1.114	1.190	1.153	1.189	1.126	1.154	1.207	1.129	1.196	1.241	1.166	+34
Normal (1873–99)	1.174	1.162	1.126	1.100	1.078	1.080	1.111	1.121	1.157	1.149	1.157	1.165	1.132	....
Departure (in thousandths)	+42	+30	−6	−32	−54	−52	−21	−11	+25	+17	+25	+33	....	....
Correction for sea-level, add	0.921	0.913	0.899	0.895	0.882	0.875	0.869	0.874	0.883	0.891	0.908	0.915	0.893	....
Mean sea-level	2.095	2.075	2.025	1.995	1.960	1.955	1.980	1.995	2.040	2.040	2.065	2.080	2.025	....

* Not included in average departure.

Table CXL contains values which added to a base of 28.000 inches equal the mean monthly and annual station barometric pressure. Elevation of barometer 823 ft. above sealevel. The last column contains for each year the departure in thousandths of an inch from the normal annual pressure, based upon records from 1873 to 1899. The corrections to be added to the station pressure for reduction to sealevel and the sea-level readings themselves are also given.

MEAN STATION PRESSURE, MONTHLY AND ANNUAL

The actual pressure at any place in the temperate zone varies considerably in the course of a year, but the fluctuations are usually well within 1 inch above or below the normal. Table CXL gives the average station pressure—that is, the pressure at the elevation of 823 feet—for each month and year from 1873–1913, inclusive. In order to simplify the data as much as possible, only the excess of pressure over 28.000 inches has been entered, and that amount must be added to the values in order to secure the station pressure. For instance, the mean station pressure for January, 1873, was (28.000+1.123) 29.123 inches, while that for April, 1878, was (28.000+0.894) 28.894 inches. According to the table, the mean pressure at the station elevation is 29.132 inches, which reduced to the level of the sea becomes 30.025 inches. On the average the pressure is highest in January, 29.174 inches, and lowest in May, 29.078 inches. Reduced to sea level these values become 30.095 and 29.960 inches, respectively; but, owing to the influence of temperature, the lowest sea-level average occurs in June, 29.955 inches. Barometer normals were established by the Weather Bureau for the period 1873–99, inclusive. As these figures have continued in use up to the present time (1914), they only, being the means for that period, are given in the table, and are used in all cases in calculating departures.

MEAN DEPARTURE FROM NORMAL PRESSURE, MONTHLY AND ANNUAL

In calculating the mean departures from the station normal pressures, the normals for the various months have been used in each case instead of the normal pressure for the entire year, but the average departure from the annual normal is given across the bottom of Table CXLI.

HIGHEST AND LOWEST PRESSURES AT CHICAGO, REDUCED TO SEA LEVEL

Table CXLII contains the highest and lowest sea-level pressures observed at Chicago, by years. The highest pressure ordinarily occurs during the passage of a cold wave and the lowest during a severe disturbance with accompanying high winds. The mean of these highest pressures is 30.76 inches, and that of the lowest, 29.21 inches, making the mean annual range of 1.55 inches. The absolute

TABLE CXLI

MONTHLY AND ANNUAL DEPARTURES FROM NORMAL STATION PRESSURE, 1873–1913

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1873........	−.051	−.010	+.020	−.072	−.006	−.030	+.039	+.029	−.043	−.022	−.082	+.032	−.012
1874........	+.063	+.035	+.029	+.083	+.027	+.007	−.005	+.003	−.011	+.063	+.028	+.043	+.030
1875........	+.126	+.023	−.028	−.011	−.023	+.006	−.007	−.027	−.005	−.058	+.011	−.149	−.012
1876........	−.004	+.004	−.025	−.015	+.013	−.082	−.002	+.024	−.044	−.099	−.067	+.013	−.024
1877........	+.048	+.102	+.005	−.040	+.052	−.054	−.028	−.040	−.027	−.051	−.023	+.021	−.004
1878........	−.035	−.120	−.097	−.206	−.037	−.032	−.016	−.103	−.008	−.051	−.034	−.022	−.064
1879........	+.027	+.014	+.038	−.006	+.057	+.021	−.035	−.033	+.031	+.076	+.005	+.003	+.017
1880........	−.059	−.026	+.043	−.066	+.011	−.012	−.016	+.009	−.004	+.009	+.103	+.021	+.001
1881........	+.040	+.028	−.151	−.008	+.049	−.044	+.016	+.011	+.003	+.027	+.004	+.027	−.007
1882........	+.039	−.044	+.010	+.030	+.008	−.083	+.017	−.022	+.031	−.027	+.073	+.011	+.003
1883........	+.036	+.169	+.107	−.054	−.040	−.055	−.015	+.057	+.021	+.055	+.014	+.006	+.025
1884........	+.059	−.046	−.012	−.054	−.034	+.064	−.082	+.019	−.034	+.065	+.017	+.017	−.002
1885........	+.031	−.077	+.030	+.009	−.055	+.043	−.036	−.032	−.018	−.064	−.090	−.032	−.025
1886........	−.038	−.008	−.067	+.047	−.011	+.004	−.022	−.035	−.005	+.126	−.049	+.084	+.002
1887........	−.122	+.056	+.045	−.050	+.011	+.011	−.028	−.005	+.026	+.008	−.001	−.014	−.006
1888........	+.143	−.010	+.082	+.147	−.046	−.036	+.038	+.033	+.022	−.071	+.075	+.003	+.031
1889........	−.083	+.053	−.016	+.019	−.013	+.011	−.015	+.069	−.026	+.092	+.011	−.011	+.007
1890........	+.057	−.016	+.040	+.097	−.051	+.013	+.020	+.057	+.057	−.104	−.003	+.016	+.015
1891........	−.035	−.068	−.005	+.010	+.137	−.024	+.032	−.011	+.076	+.058	−.005	−.037	+.010
1892........	+.005	+.021	+.030	+.039	−.071	−.039	+.075	+.025	+.040	+.017	−.005	+.016	+.012
1893........	−.015	+.014	−.030	−.109	−.061	+.005	−.011	+.023	−.050	−.040	−.039	−.006	−.036
1894........	−.024	+.025	−.036	+.003	−.020	+.032	+.032	+.036	−.007	−.111	−.003	+.008	−.006
1895........	+.007	+.038	−.007	+.008	+.036	+.076	+.012	−.056	−.037	+.013	+.034	−.086	−.006
1896........	+.042	−.132	+.021	+.029	−.022	+.018	+.024	+.025	−.019	+.009	−.048	+.087	+.010
1897........	+.009	−.015	−.010	+.050	+.046	+.006	−.046	−.006	+.115	+.031	+.004	−.012	+.014
1898........	−.076	−.002	+.057	+.066	−.016	+.031	+.046	−.018	−.023	−.036	−.028	−.020	−.002
1899........	+.007	−.019	−.067	+.029	+.055	+.082	+.003	−.009	+.030	+.088	+.003	−.022	+.015
1900........	−.023	−.060	+.026	+.054	+.011	+.007	−.013	+.031	+.026	+.058	+.017	−.005	+.010
1901........	−.041	+.001	−.186	+.115	−.065	−.007	−.015	+.022	+.004	+.077	+.069	−.020	−.003
1902........	+.067	−.057	−.047	−.025	+.052	−.029	+.007	+.005	−.050	+.002	−.028	+.010	−.008
1903........	−.014	+.017	+.125	−.068	+.081	+.017	+.009	−.009	+.046	+.061	+.047	−.020	+.016
1904........	−.003	+.109	−.020	+.047	−.003	+.043	+.025	+.063	+.036	+.043	+.015	−.046	+.025
1905........	+.133	+.137	+.038	−.063	−.017	+.012	−.049	−.013	−.006	+.056	−.015	+.014	+.019
1906........	−.047	+.163	+.082	+.051	+.014	−.050	−.007	−.004	+.028	−.012	+.087	+.079	+.032
1907........	+.092	+.053	+.014	−.007	+.026	−.033	−.047	+.027	−.042	+.072	+.017	−.070	+.008
1908........	−.063	−.009	+.012	−.055	−.085	+.068	+.069	+.030	+.038	+.084	−.031	−.018	+.003
1909........	+.057	−.146	−.092	−.041	−.049	+.042	−.003	+.047	+.073	+.038	+.061	−.076	−.008
1910........	−.001	+.074	+.042	−.091	+.061	+.048	−.043	+.010	+.037	−.021	−.052	+.031	+.008
1911........	+.048	+.060	+.015	+.089	+.070	+.006	+.019	+.031	+.018	+.029	−.052	+.039	+.031
1912*.......	+.015	−.043	+.134	−.021	−.043	+.090	+.035	−.044	−.006	+.030	−.011	−.086	+.004
1913*.......	−.040	+.003	−.012	+.090	+.075	+.109	+.015	+.033	+.050	−.020	+.039	+.076	+.034
Normal.....	1.174	1.162	1.126	1.100	1.078	1.080	1.111	1.121	1.157	1.149	1.157	1.165	1.132
Departure...	+.042	+.030	−.006	−.032	−.054	−.052	−.021	−.011	+.025	+.017	+.025	+.033	....

* Not included in average departure.

Table CXLI contains the monthly and annual departures (in thousandths) of pressure from the normal values, based upon records from 1873 to 1899. To these normals must be added the base of 28.000 inches. In this table is also given the average monthly departure. See Table CXL.

TABLE CXLII

HIGHEST AND LOWEST OBSERVED SEA-LEVEL PRESSURES, 1872–1913

Year	Highest	Lowest	Year	Highest	Lowest	Year	Highest	Lowest	Year	Highest	Lowest
1872.....	30.76	29.33	1884....	30.66	29.29	1896....	30.71	29.37	1908....	30.75	29.22
1873.....	30.75	29.31	1885....	30.71	29.18	1897....	30.74	29.29	1909....	30.63	29.04
1874.....	30.80	29.15	1886....	30.66	29.09	1898....	30.82	29.27	1910....	30.76	29.26
1875.....	30.71	29.12	1887....	30.81	29.03	1899....	30.76	29.24	1911*...	30.77	29.27
1876.....	30.62	29.25	1888....	30.93	29.28	1900....	30.61	29.20	1912*...	30.72	29.32
1877.....	30.70	29.17	1889....	30.86	29.31	1901....	30.72	29.31	1913*...	30.67	29.31
1878.....	30.64	29.22	1890....	30.74	29.29	1902....	30.94	29.11			
1879.....	30.66	29.24	1891....	30.68	29.19	1903....	30.70	29.13	Mean...	30.76	29.21
1880.....	30.79	29.01	1892....	30.67	29.16	1904....	30.74	29.06	Extremes	30.94	28.98
1881.....	30.69	29.23	1893....	30.94	28.98	1905....	30.78	29.18	Years...	{1893 / 1902}	1893
1882.....	30.72	29.25	1894....	30.85	29.26	1906....	30.72	29.03		Range...1.96	
1883.....	30.72	29.43	1895....	30.65	29.20	1907....	30.71	29.18			

* Not included in means.

TABLE CXLIII

MEAN HOURLY BAROMETRIC PRESSURE, BY MONTHS

Month	Hour Ending																								Means
	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Mdt.	
January	.148	.154	.153	.149	.147	.152	.162	.168	.176	.178	.169	.148	.133	.128	.132	.138	.143	.150	.154	.156	.156	.156	.153	.150	.152
February	.157	.156	.153	.152	.155	.159	.169	.173	.176	.179	.178	.166	.151	.141	.141	.142	.146	.153	.157	.159	.161	.161	.160	.160	.159
March	.125	.121	.116	.116	.119	.126	.135	.138	.142	.143	.141	.135	.123	.111	.107	.106	.109	.112	.117	.124	.128	.130	.130	.128	.124
April	.120	.118	.117	.117	.123	.132	.143	.143	.147	.148	.144	.137	.130	.119	.111	.109	.108	.109	.113	.122	.128	.129	.128	.125	.126
May	.092	.090	.091	.094	.102	.110	.119	.122	.122	.122	.119	.112	.105	.096	.088	.083	.080	.079	.080	.088	.096	.098	.098	.097	.099
June	.096	.096	.097	.103	.111	.119	.128	.130	.129	.129	.127	.121	.112	.104	.096	.089	.084	.084	.084	.091	.099	.103	.104	.099	.106
July	.128	.127	.128	.133	.139	.147	.155	.160	.160	.160	.158	.152	.144	.135	.126	.117	.111	.110	.111	.118	.126	.129	.131	.131	.135
August	.132	.132	.132	.135	.141	.150	.158	.160	.163	.164	.159	.152	.144	.133	.125	.119	.115	.115	.119	.128	.133	.136	.137	.135	.138
September	.173	.173	.174	.176	.182	.192	.200	.204	.207	.206	.202	.192	.180	.169	.161	.157	.156	.157	.161	.169	.173	.175	.176	.175	.179
October	.174	.174	.173	.177	.181	.187	.196	.201	.202	.201	.196	.182	.168	.159	.156	.155	.158	.162	.165	.169	.172	.173	.171	.174	.176
November	.172	.175	.172	.172	.175	.177	.186	.191	.193	.194	.186	.171	.160	.153	.154	.158	.164	.171	.174	.176	.177	.177	.176	.174	.174
December	.157	.161	.160	.156	.155	.160	.169	.171	.179	.184	.174	.157	.144	.139	.142	.150	.155	.160	.164	.166	.166	.168	.168	.161	.161
Annual means	.140	.140	.139	.140	.144	.151	.160	.163	.166	.167	.163	.152	.141	.132	.128	.127	.127	.130	.133	.139	.143	.145	.144	.142	.144

Table CXLIII contains the values which added to a base of 29.000 inches will give the mean hourly barometric station pressure for each month; these means are taken from records from 1891 to 1904, and are graphically shown in Fig. 71.

extremes are 30.94 and 28.98 inches, respectively, and the absolute range, therefore, is 1.96 inches. The highest absolute pressure occurred on two occasions, February 4, 1893, during a well-marked cold wave in which the temperature fell to −8°, and on January 28, 1902, in a cold wave with a minimum temperature of −4°. The lowest reading, 28.98 inches, occurred on April 20, 1893, thus bringing the absolute extremes of pressure within three months of each

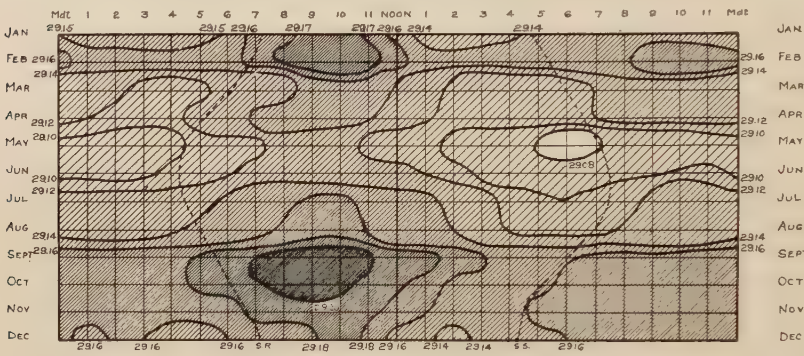


FIG. 71.—Mean hourly pressure.

Fig. 71 shows the mean barometric station pressure for each hour of the day and each month of the year based upon records from 1891 to 1904. The areas of deepest shading indicate the times of greatest pressure and vice versa. The dotted lines, *S.R.* and *S.S.*, indicate the varying times of sunrise and sunset. These values are taken from Table CXLIII.

other. A severe storm prevailed on the last-named date, with rain turning to snow, and a very high wind, which reached a velocity of 72 miles an hour. The storm was followed by a sharp drop in temperature, from 48° on April 20 to 30° on the 21st, a very low reading for that period of the year. Considerable damage was done to shipping in the lakes by the high westerly gale, which continued during the 21st.

MEAN HOURLY PRESSURE BY MONTHS

Table CXLIII contains the average hourly pressure readings by months, and the values are well illustrated in Fig. 71. In the table are given the decimals only, and in reading the amounts each must be added to 29.000 inches. The pressures in both table and graph are for the station elevation of 823 feet. Primary and secondary maxima and minima are apparent from a study of the data, the primary maximum occurring at from 9 to 10 A.M., and the primary

minimum from 2 to 3 P.M. in the colder months, and from 2 to 6 P.M. in the warm season. The secondary maximum follows the primary minimum in the evening, and the secondary minimum occurs in the early morning, before the primary maximum. While the highest average monthly pressure occurs in January, as shown in Table CXLII, the highest average hourly reading occurs at 9 A.M. in the month of September. The explanation of these variations in pressure is unimportant, so far as the main features of weather and climate at Chicago are concerned, but should further information be desired reference may be had to any standard textbook on meteorology. In Fig. 72 are given graphically the curves of pressure change during the course of the day, for the months of January, April, July, and October, and the year.

MEAN HOURLY PRESSURE DEPARTURES

In the swing of pressure through the diurnal period the pressure is first above the normal pressure for the day and then below, as indicated in Fig. 72, in the previous paragraph. Table CXLIV presents the hourly departures from the mean daily pressure for each month of the year. The period of greatest departure varies, and the changes are somewhat abrupt from the primary maximum in the morning to the primary minimum in the afternoon, especially in winter, when the latter occurs earlier than it does in other seasons. In the hours where the departures are zero (.000) the values just equal the mean daily pressures for the month. Whenever the zero departure does not occur in the table, the mean daily pressure is reached between the hours in which the departure changes from positive (+) to negative (−), or vice versa.

PRESSURE PHASES

The pressure phases contained in Table CXLV have been prepared along the same lines as the similar tables showing the temperature and sunshine phases (pp. 135, 263), for the purpose of determining more exactly than is possible with hourly values the time of occurrence of the maxima and minima in the different months of the year.

RELATION BETWEEN PRESSURE AND OTHER CONDITIONS ILLUSTRATED

In Fig. 73 is given a particular instance of the relation between pressure change and those of temperature and wind direction and velocity. Ordinarily, when the barometer falls the temperature rises,

TABLE CXLIV

MEAN HOURLY DEPARTURES FROM MEAN DAILY PRESSURES, BY MONTHS

Month	Hour Ending																							
	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Mdt.
Jan.....	−.004	+.002	+.001	−.003	−.005	000	+.010	+.016	+.024	+.026	+.017	−.004	−.019	−.024	−.020	−.014	−.009	−.002	+.002	+.004	+.004	+.004	+.001	−.002
Feb.....	−.002	−.003	−.006	−.007	−.004	000	+.010	+.014	+.017	+.020	+.019	+ 007	−.008	−.018	−.018	−.017	−.013	−.006	−.002	000	+.002	+.002	+.001	+.001
Mar....	+.001	−.003	−.008	−.008	−.005	+.002	+.011	+.014	+.018	+.019	+.017	+.011	−.001	−.013	−.017	−.018	−.015	−.012	−.007	000	+.004	+.006	+.006	+.004
April....	−.006	−.008	−.009	−.009	−.003	+.006	+.017	+.017	+.021	+.022	+.018	+.011	+.004	−.007	−.015	−.017	−.018	−.017	−.013	−.004	+.002	+.003	+.002	−.001
May ...	−.007	−.009	−.008	−.005	+.003	+.011	+.020	+.023	+.023	+.023	+.020	+.013	+.006	−.003	−.011	−.016	−.019	−.020	−.019	−.011	−.003	−.001	−.001	−.002
June....	−.010	−.010	−.009	−.003	+.005	+.013	+.022	+.024	+.023	+.023	+.021	+.015	+.006	−.002	−.010	−.017	−.022	−.022	−.022	−.015	−.007	−.003	−.002	−.007
July ...	−.007	−.008	−.007	−.002	+.004	+.012	+.020	+.025	+.025	+.025	+.023	+.017	+.009	000	−.009	−.018	−.024	−.025	−.024	−.017	−.009	−.006	−.004	−.004
Aug....	−.006	−.006	−.006	−.003	+.003	+.012	+.020	+.022	+.025	+.026	+.021	+.014	+.006	−.005	−.013	−.019	−.023	−.023	−.019	−.010	−.005	−.002	−.001	−.003
Sept....	−.006	−.006	−.005	−.003	+.003	+.013	+.021	+.025	+.028	+.027	+.023	+.013	+.001	−.010	−.018	−.022	−.023	−.022	−.018	−.010	−.006	−.004	−.003	−.004
Oct.....	−.002	−.002	−.003	+.001	+.005	+.011	+.020	+.025	+.026	+.025	+.020	+.006	−.008	−.017	−.020	−.021	−.018	−.014	−.011	−.007	−.004	−.003	−.005	−.002
Nov....	−.002	+.001	−.002	−.002	+.001	+.003	+.012	+.017	+.019	+.020	+.012	−.003	−.014	−.021	−.020	−.016	−.010	−.003	000	+.002	+.003	+.003	+.002	000
Dec.....	−.004	000	−.001	−.005	−.006	−.001	+.008	+.010	+.018	+.023	+.013	−.004	−.017	−.022	−.019	−.011	−.006	−.001	+.003	+.005	+.005	+.007	+.007	000

Table CXLIV shows the hourly departures from the mean of the daily barometric pressure for each month, expressed in thousandths of an inch.

and when the barometer rises the temperature falls. In the case in the graph, however, the fall shown up to 8 A.M. was unaccompanied by any considerable rise in temperature because of the snow and the heavily clouded condition. After 8 A.M. the pressure began to rise, and the wind, which had been from the south and southwest, changed to west. The temperature fell rapidly, the amount between 8 and 10 A.M. being 20°. In advance of a cold wave, such as the one illustrated here, there is usually a considerable fall in pressure,

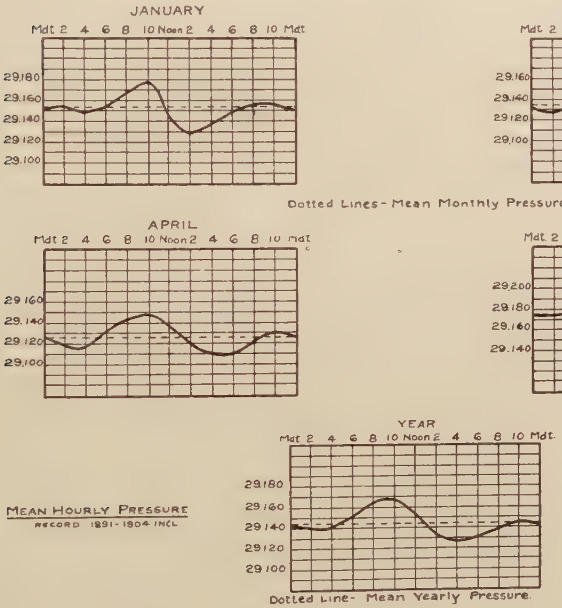


FIG. 72.

Fig. 72 contains the mean hourly pressure curves for the months of January, April, July, October, and for the year, based upon records from 1891 to 1904.

followed by a rise accompanied by brisk to high winds shifting to west or northwest, the temperature beginning to fall with the change in direction.

The relation indicated above is not so close in the summer season. In the upper portion of Fig. 74 a period of two days is shown, July 20 and 21, 1907. The changes in temperature and pressure on the first day of the period were small, with east to north winds; but on the second day, with falling barometer the temperature

TABLE CXLV

PRESSURE PHASES

	Morning Maximum						Afternoon Minimum								
	A.M.					Average A.M.	P.M.								Average P.M.
	7	8	9	10	11		12 Nn	1	2	3	4	5	6	7	
January	...	...	3	11	...	9:45	...	1	11	2	...	...	...	...	2:10
February	...	...	4	8	4	10:00	...	...	6	7	5	...	...	...	3:00
March	1	...	5	8	4	9:45	...	...	3	3	9	3	...	...	3:50
April	...	1	7	11	2	9:45	...	...	...	3	3	3	5	2	5:00
May	2	4	...	9	1	9:15	...	...	...	...	2	3	8	4	5:50
June	1	8	3	2	2	8:45	...	...	...	...	...	4	5	6	6:08
July	...	6	5	8	2	9:15	...	...	...	...	...	3	8	5	6:08
August	1	...	4	11	...	9:30	...	...	...	1	...	5	8	1	5:30
September	...	4	8	5	1	9:10	...	...	...	...	4	6	8	...	5:10
October	...	5	8	5	...	9:00	...	...	...	6	10	3	...	...	3:50
November	1	4	3	8	...	9:10	...	1	11	5	...	...	...	...	2:15
December	...	...	2	13	...	9:50	...	2	11	1	...	...	...	...	2:00
Sums	6	32	52	99	16		...	4	42	28	33	30	42	18	
Annual average	0	3	4	8	1	9:30	...	0	4	2	3	2	4	2	4:20

	Night Maximum									Night Miminum									
	P.M.						A.M.		Average P.M.	P.M.		A.M.						Average A.M.
	7	8	9	10	11	12	1	2		11	12	1	2	3	4	5	6	
January	1	3	3	2	2	3	...	2	9:00	2	1	6	...	...	1	6	...	2:45
February	2	3	4	5	4	...	...	...	9:20	4	...	1	1	4	7	1	...	3:45
March	...	...	2	5	5	6	3	3	11:30	4	...	...	...	6	8	...	1	3:15
April	...	...	3	5	3	5	...	1	10:50	2	...	2	3	5	6	...	...	2:10
May	...	...	2	3	4	6	1	...	11:30	3	...	...	5	5	1	...	...	2:20
June	...	...	...	4	9	3	1	...	11:00	...	1	7	4	3	1	...	...	1:45
July	...	...	...	2	5	8	2	...	11:35	3	1	4	8	6	...	...	...	1:50
August	...	...	...	5	12	4	1	...	11:00	...	...	5	6	8	1	...	...	2:15
September	...	...	2	6	4	3	1	1	10:50	4	2	3	6	4	1	...	...	2:05
October	...	1	4	6	2	4	2	2	10:50	7	3	2	3	6	...	...	...	1:55
November	...	2	4	2	5	4	...	...	10:20	4	2	3	1	1	5	2	1	2:10
December	2	1	...	5	6	3	...	2	10:40	1	1	5	...	1	1	8	2	3:30
Sums	5	10	24	50	61	49	11	11		34	11	40	37	49	32	17	4	
Annual average	0	1	2	4	5	4	1	1	10:50	3	1	3	3	4	3	2	0	2:35

Table CXLV shows the pressure phases, giving the number of times each month during the period from 1891 to 1904 that the morning maximum, afternoon minimum, night maximum, and night minimum pressure readings have occurred at the hours mentioned, together with the average monthly and annual times of occurrence.

rose to 90°, with south to southwest winds. Although the barometer rose slightly thereafter, the fall in temperature following was mainly that of the diurnal change. In the second period, July 1 and 2, 1911, shown at the bottom of the graph, the temperature rose on the first day to a maximum of 96° from a minimum of 75°, and on the second day to a maximum of 98° from a minimum of 79°. The changes

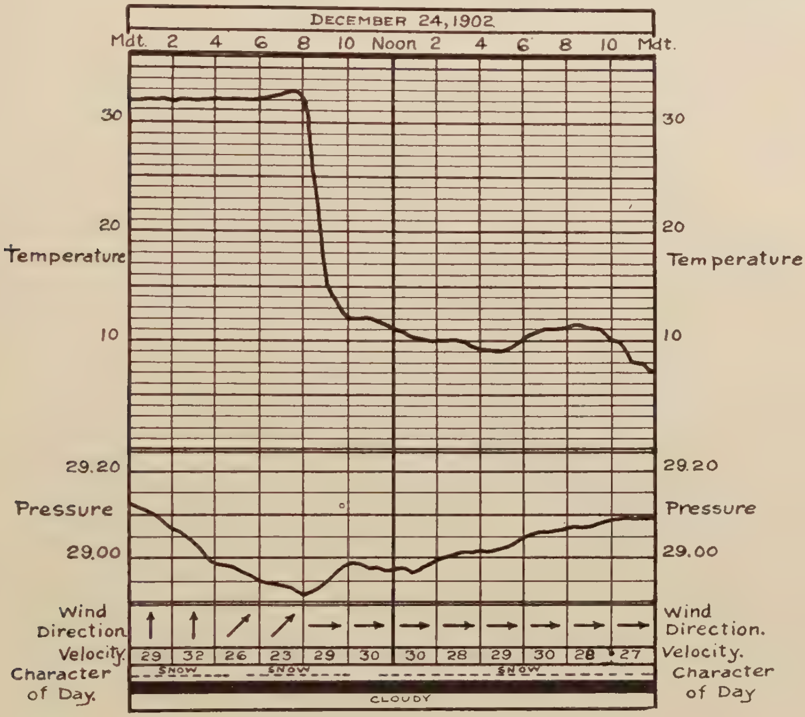


FIG. 73.—Example of a cold wave.

Fig. 73 shows the various conditions of weather immediately preceding and during the prevalence of a cold wave, midnight to midnight, December 24, 1902.

in pressure on both days were slight, but the tendency was downward to the amount of a little more than the diurnal change.

Fig. 75 illustrates all the weather conditions as recorded in Chicago on a single day. The figure is a copy of the daily local record for December 27, 1904, on which day a severe storm from the southwest moved directly across the Great Lakes. The map in the lower right-hand corner shows the storm center in the morning

close to Chicago. The heavy lines, or isobars, indicate a considerable pressure gradient, as they are crowded closely together from southwest to northwest. The temperature conditions over the country, shown by the dotted lines, indicate the presence of a cold wave in the northwest, and this followed in after the passage of the storm. The barometer curve shows the changes at Chicago, decreasing until about noon, and then increasing as the storm center passed the city. With

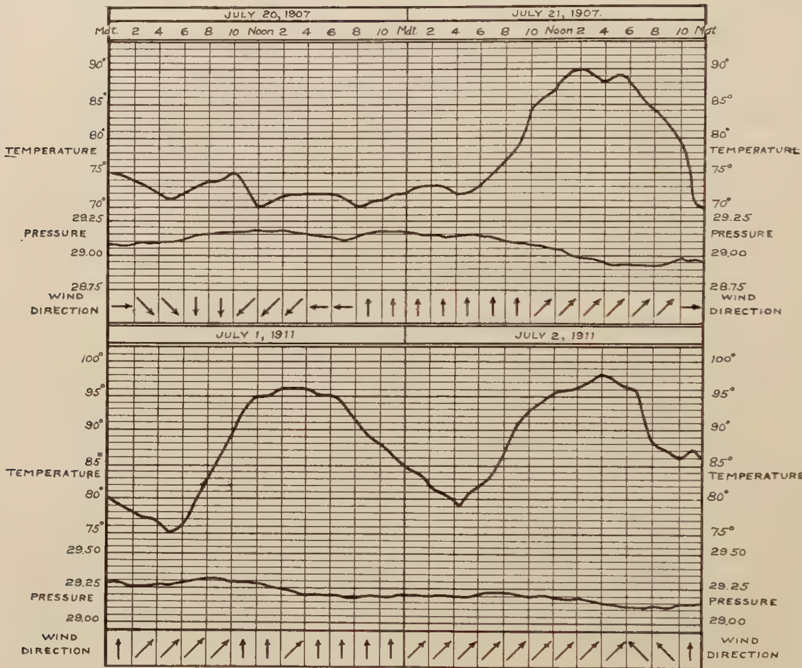


FIG. 74.—Examples of warm days.

Fig. 74 shows the temperature and pressure curves and direction of wind on July 20–21, 1907, and July 1–2, 1911, two periods of warm weather.

the rise in barometer the wind, which had been from the northeast and east, shifted to south between 10 and 11 A.M., and to southwest by noon. The storm moved to the northeastward with its center passing west of Chicago. Had it passed to the south of the city the change in wind direction would have been the opposite of what actually occurred, and it would have veered through north to northwest. As it was, the center moved to the north so far that the wind after the shift held to southwest instead of going around to northwest, as is

usually the case, and became high, the gale lasting from 11 A.M. until after midnight, with a velocity of 72 miles an hour occurring several times during the course of the afternoon. With the shift to southwest the temperature fell rapidly, from 43° at 11 A.M. to 11°

DAILY LOCAL RECORD.

(Station) CHICAGO, ILL. December 27th, 1904 (Date)

	A. M.												P. M.											
Time (local standard), 90 mer	12–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Temperature at end of hour	37	37	36	36	36	36	36	36	36	36	43	34	28	19	15	12	11	11	11	12	13	12	11	10
State of weather. Nature of precipitation and time of beginning and ending	D.N.—Mist & occasional light rain turning to snow at noon—E12:15												B.1:15—Light snow—D.N.											
Amount of precipitation	Depth of snowfall, 0.2 inch												Precipitation, inc. melted snow, .24 in											
Cloudiness and other conditions	Cloudy																							
	Sunrise Time, Character, 7:28 Cloudy																				Sunset Time, Character, 4:34 Cloudy			
Sunshine (in tenths of hours)								0	0	0	0	0	0	0	0	0	0							
Wind direction	NE	NE	NE	NE	NE	NE	NE	E	E	E	SE	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Wind movement	14	15	17	17	18	18	19	19	19	19	24	39	51	61	58	61	62	59	54	49	46	45	44	39
Maximum velocities (exceeding 25 miles)											26	56	61	72	70	72	72	72	59	54	52	52	50	50

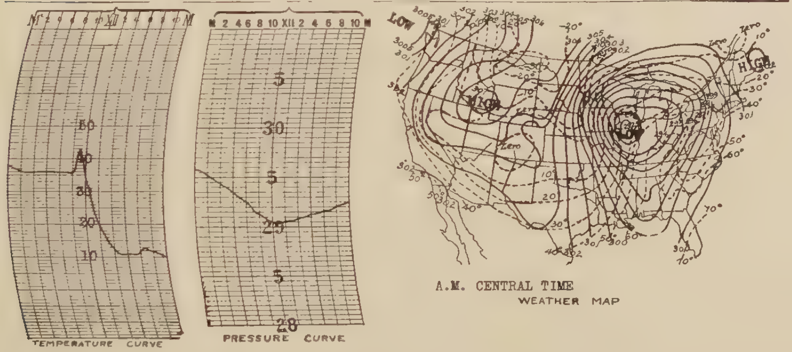


FIG. 75.

Fig. 75 is a copy of the Chicago Daily Local Record for December 27, 1904, showing all the conditions of weather prevailing on that day. A similar record is made out for each day of the year.

at 5 P.M. The figure as a whole shows the marked response in the conditions of temperature, wind direction, and velocity to the changes of pressure as the storm passed west and north of the city. The general characteristics of the storm will be given more in detail in a later paragraph (p. 342).

PART VII

STORM TRACKS

As stated in the introduction Chicago is close to the paths of certain types of storms, the average routes of which are indicated in Fig. 76. The southwest storms pass very close to the city, as a rule, and their passage is preceded by northeast winds. Those whose centers cross the Southwest as far north as Oklahoma usually pass directly over Chicago or somewhat to the north of the city, and under such conditions the northeast wind shifts around through southeast

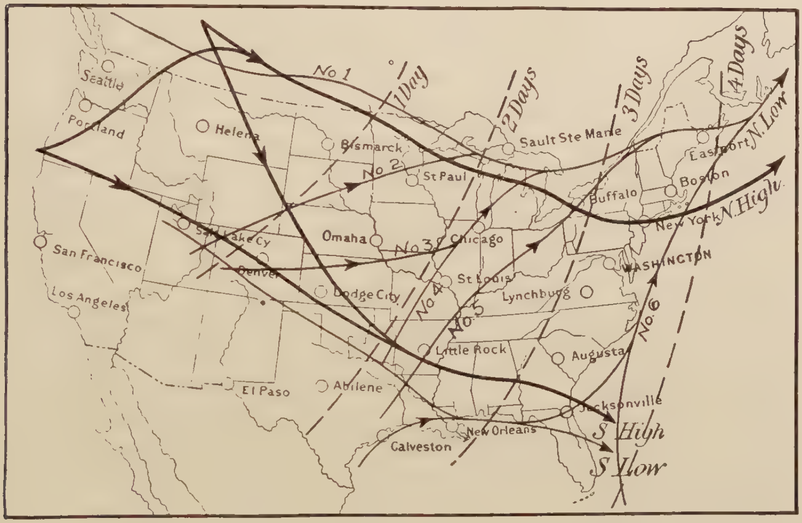


FIG. 76.—Mean tracks and average daily movement of storms in the United States.

and south to southwest and west (track 4). Occasionally, however, the centers of such disturbances pass up the Ohio Valley, or so far to the southward that Chicago is only on the edge of the storm, or is beyond it altogether, if it is not extensive (track 5). The most frequent storms are those which move from the far Northwest and pass with their centers over the northern Lake region (track 1). Chicago is generally on the southern edge of storms of this kind, or at least well within the storm area, and experiences south to southwest winds, shifting later to northwest as the disturbances move eastward.

Another track (track 2), but one less frequently followed, is that from the middle western plateau region northeastward, merging with track 1 over the upper Michigan peninsula, with Chicago on the southern edge. A still less frequented track is track 3, although the storms which follow it are likely to be severe. It extends from the middle Rocky Mountain region eastward across the southern Lake sections, and might appropriately be termed the "overland route." Such storms are attended by southeast and south winds shifting to west and northwest. Taken as a class, storms usually pursue a path extending somewhat to the north of east, although those approaching from the far northwest, as a rule, turn southeastward over the Lakes.

The areas of high pressure usually move in a general south-of-east direction, but both high- and low-pressure areas are carried eastward by the general circulation of the atmosphere, as an eddy is carried along in a stream of water. The exact direction of the individual area is controlled by the configuration of the surface of the ground, and by the distribution of pressure and temperature existing at the time. Areas of high pressure usually bring cool weather, and always accompany the cold waves of the winter season. In the figure the heavy lines indicate the paths of high-pressure areas, and the light lines, those of the areas of low pressure. These paths are as originally charted by Bigelow, except that there have been added the "overland track," and that from the south extending northeastward over the Ohio Valley (tracks 3 and 5), which were not given by Bigelow. The average daily movement of the various areas is shown by the broken lines successively spaced for 1, 2, 3, and 4 days.

The northeast blows of winter, due to the approach of storms from the southwest, are usually accompanied by snow (p. 216), especially after the temperature of the water of the lake has fallen to the freezing point, late in December. Other storms which pass over Chicago in the winter time are accompanied either by rain or snow, depending upon the temperature of the air and the exact position of the path of the storm center. The farther north the center, the greater is the likelihood of rain instead of snow.

There are practically no storms moving from the southwest over Chicago in the summer time, the prevailing northeast winds of that season being due to an entirely different cause (p. 145). A track of many summer storms is close to that of the "overland route" of winter storms. The route across the Lake region in summer changes

little from that of winter, but in the spring these storms move farther to the south.

All the storm tracks over the Middle States, whether they pass across the northern Lake region, directly over Chicago, or up the Ohio Valley, merge into a single track in the upper valley of the St. Lawrence River, together with that which stretches north-north-eastward along the Atlantic coast.

TRACKS OF SELECTED STORMS, COLD WAVES, AND HOT WAVES

In the succeeding pages further reference will be made to the movement of storms which affect the weather conditions of Chicago, but the accompanying charts can be used to best advantage only by those who understand the weather map. The lines of equal air pressure, or isobars, are drawn for each 0.10 inch of pressure; the temperature lines, or isotherms, are drawn dotted for each 10° difference in temperature. Storm centers are marked LOW, while the centers of cold areas are marked HIGH, and indicate areas of low and high pressure, respectively. Areas of precipitation occurring during the previous twenty-four hours are shaded. The surface wind ordinarily blows from the high to the low pressures. That is, its direction is usually outward from the HIGH and inward toward the LOW.

Figs. 77 and 78 show the passage of a storm on November 21 to 23, 1903, eastward and southeastward over the northern Lake region along the most northerly track of storms (No. 1, Fig. 76). As will be seen in the last of the two figures, the rainfall areas barely reached Chicago, and the weather conditions as a consequence of the storm's movement were not important.

The passage of a storm along the "overland route" is illustrated in Figs. 79 and 80, which show the movement of the storm of January 20 and 21, 1895. This disturbance moved quite rapidly, passing from Colorado to Lake Michigan in twenty-four hours, deepening as it advanced. The increase in energy is indicated by the low reading of the barometer and the closely crowded isobars around the storm center. As it approached, Chicago was in its southeast quadrant, and a thunderstorm occurred in the city early in the morning of January 21, although it was the middle of the winter. The center passed slightly to the northward with rain accompanying it, which turned to snow about noon of the 21st. The fall, however, was light, as is usual with disturbances of this character. A southeasterly shifting

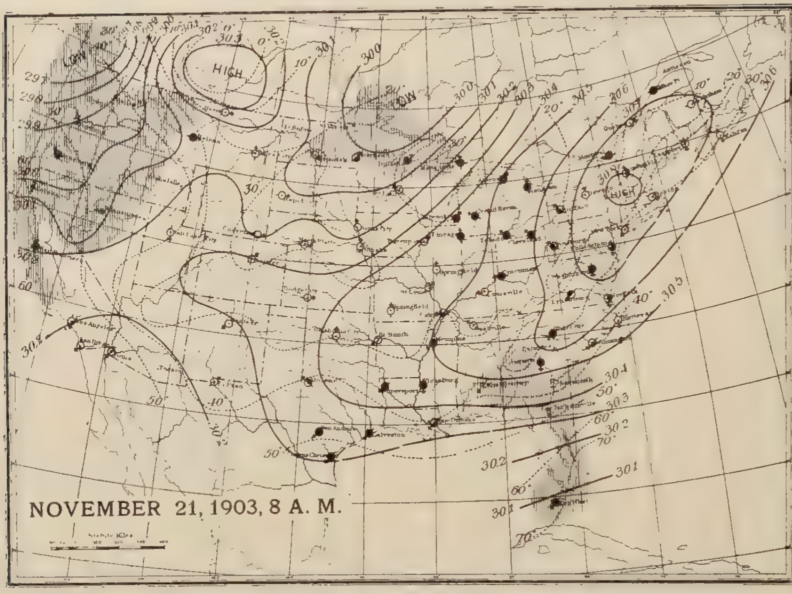


FIG. 77.

Fig. 77 shows a storm entering the United States over northwest Washington, which followed Track 1 (see Fig. 76).

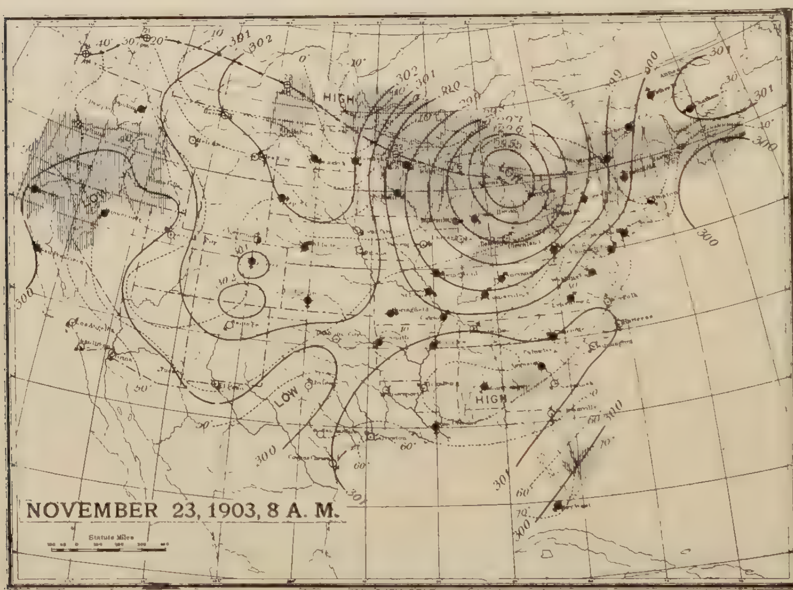


FIG. 78.

Fig. 78 shows the path of the storm referred to in Fig. 77. The location of this storm at the end of each twelve hours' progress is shown by the small circles at intervals along the track.

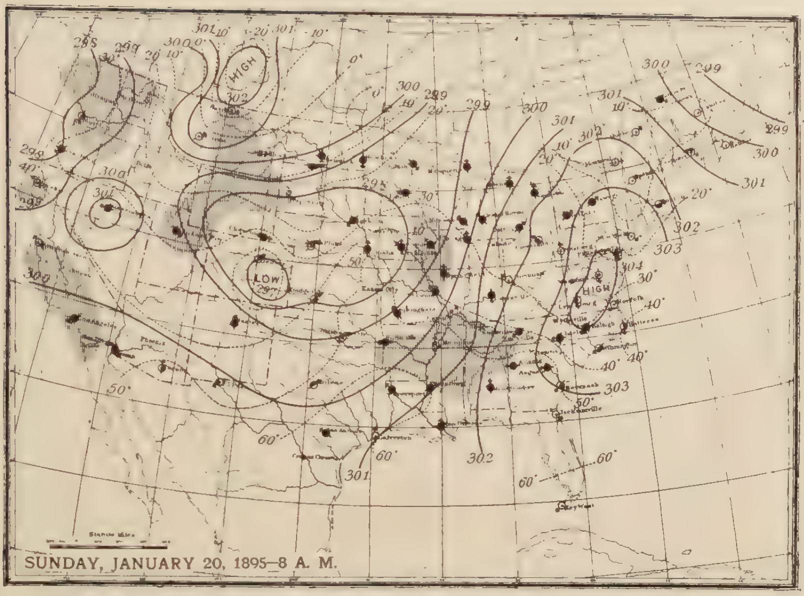


FIG. 79.

Fig. 79 shows a storm central over eastern Colorado which followed Track 3 (see Fig. 76).

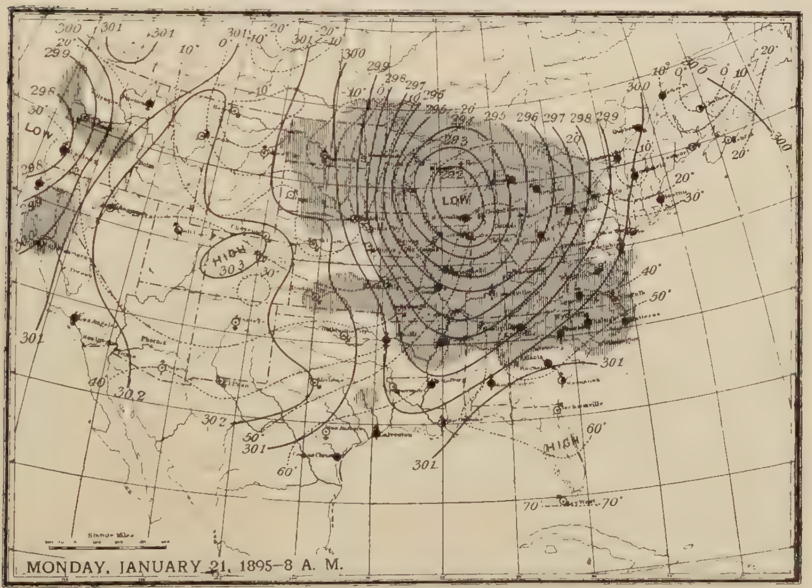


FIG. 80.

Fig. 80 shows the rapid twenty-four-hour movement of the storm referred to in Fig. 79. The storm has increased greatly in energy.

through southwest to northwest gale prevailed, reaching a maximum velocity of 64 miles an hour from the southwest, and a marked cold wave followed. The passenger steamer "Chicora" left Milwaukee early in the morning of January 21, bound for St. Joseph, Michigan, but was never heard of afterward, the vessel with its crew and few passengers being lost in the lake.

Figs. 81 and 82, weather maps of December 26 and 27, 1904, show the movement of the storm referred to in the discussion of Fig. 75 (p. 331). The track as marked out indicates that the storm passed from the North Pacific coast on December 24 southeastward across the middle Rockies, reaching Texas on the 26th. Then recurving and moving northeastward, it developed great energy, and its center passed close to Chicago on the 27th with severe shifting gales and general precipitation, and was followed by a cold wave. The precipitation was chiefly in the form of rain, as the lake wind blowing toward the disturbance in its approach raised the temperature considerably above the freezing point, where it remained until the wind shifted to southwest. The storm after reaching Texas followed the usual course (track 4, Fig. 76).

Another storm which followed nearly the same path as that illustrated in the preceding paragraph was that of February 18 and 19, 1908, shown in Figs. 83 and 84. The point at which this storm entered the country on February 16 was even farther to the north, near Puget Sound, whence it moved southeastward, reaching northwestern Arkansas in 48 hours. It then recurved and moved northeastward, passing with its center southeast of Chicago on the morning of the 19th. This disturbance was accompanied locally by severe, shifting gales with a maximum velocity of 48 miles an hour from the east, and by the heaviest snowfall on record attending any single storm, a fall of 12.7 inches of snow falling within a space of twenty-four hours (p. 222). The winds drifted the snow badly, which resulted in serious interruptions of traffic. The track of the storm, after reaching Arkansas, lay about midway between tracks 4 and 5, shown in Fig. 76.

The storm which wrecked the city of Galveston, Texas, on September 8, 1900, moved from its entry into the country at that place northeastward across the Lake region, its center passing somewhat north of Chicago, as indicated in Fig. 85. The chart shows the weather conditions prevailing at 8 P.M. on that day, but the track of the storm is marked from its first appearance in the West Indies on

September 1 until it passed down the St. Lawrence Valley on the 12th.

After its first appearance in the Windward Islands it moved slowly in a northeasterly direction. During September 3 and 4 it was south of Cuba, and by the morning of the 5th it had passed over that island. There it began to take a due northerly course, and continued in that direction directly across Key West, and by the evening of September 6 was centered to the south of Tampa, Florida. Instead of recurving to the northeast, as these storms usually do soon after having assumed a northerly direction, its course was changed to slightly north of west into the Gulf of Mexico, and here it was apparently lost for a couple of days, complete observations not being obtainable. The reason for this abnormal movement can be determined from a study of the weather maps of September 8 and the days previous. While its normal course after reaching Florida would have been to the northeast, this way was blocked by an area of high barometric pressure which covered the Atlantic coast, while the pressure was low over the interior of the United States. Hurricanes, as well as other storms, take the path of least resistance, and the disturbance was consequently shunted across the Gulf of Mexico to strike the Texas coast at Galveston. It is probable that the head of the storm, although lifted high enough to come under the sway of the prevailing westerlies above the neutral plane, as shown by its progress northward as far as Tampa, at this stage fell from the control of the upper winds, and drifted westward down the gradient toward the low area on the Great Plains, reaching Galveston before it again came well within the region of the prevailing westerlies in the upper atmosphere. The force of the storm was much intensified in its movement across the Gulf of Mexico, the barometer falling in the center to a minimum of 28.53 inches at Galveston at 8:10 P.M. The highest wind velocity recorded at Galveston was 84 miles an hour at 6:15 P.M., at which time the anemometer blew away, but it was estimated that a velocity of 120 miles an hour occurred later.

Following the night of September 8 the storm lost force. It is usual for these hurricanes, after passing from a water surface to the land, to lose energy rapidly and fill up in the center, there being less moisture for development, and the land surface through friction diminishing the air currents in rotation around the center. During the 9th and 10th it moved to Oklahoma, still further diminishing in intensity, and following northward the trough of low barometric pressure. By the morning of the 11th it had joined forces with LOW which had been in the interior for several days, and it appeared again as a well-defined storm over Iowa, the barometer falling rapidly in its front, and the winds increasing within its area.—Cox, *Bulletin 3*, Geographic Society of Chicago.

During the 11th it crossed the Great Lakes with its center directly north of Chicago, and caused winds of almost hurricane force, a

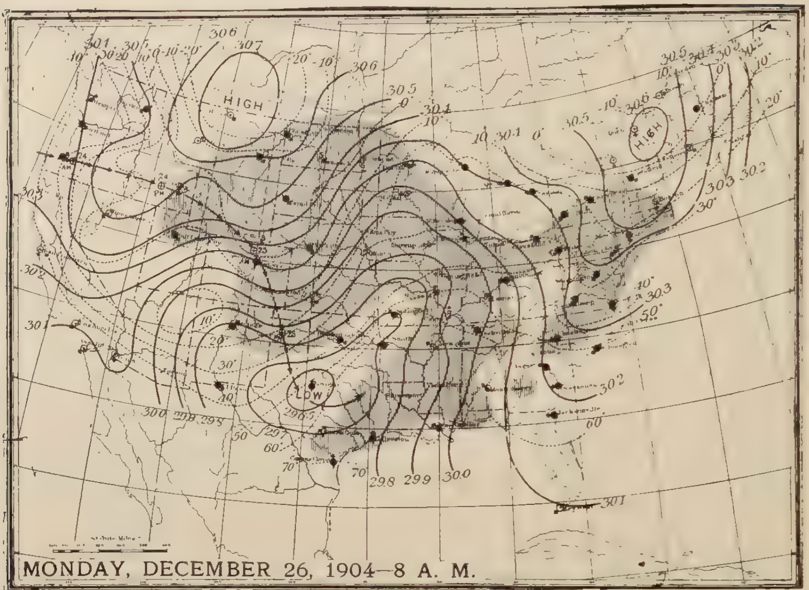


FIG. 81.

Fig. 81 shows a storm central over western Texas which after this date followed Track 4 (see Fig. 76). Each twelve hours' progress of the storm is indicated by the small circles along its path.

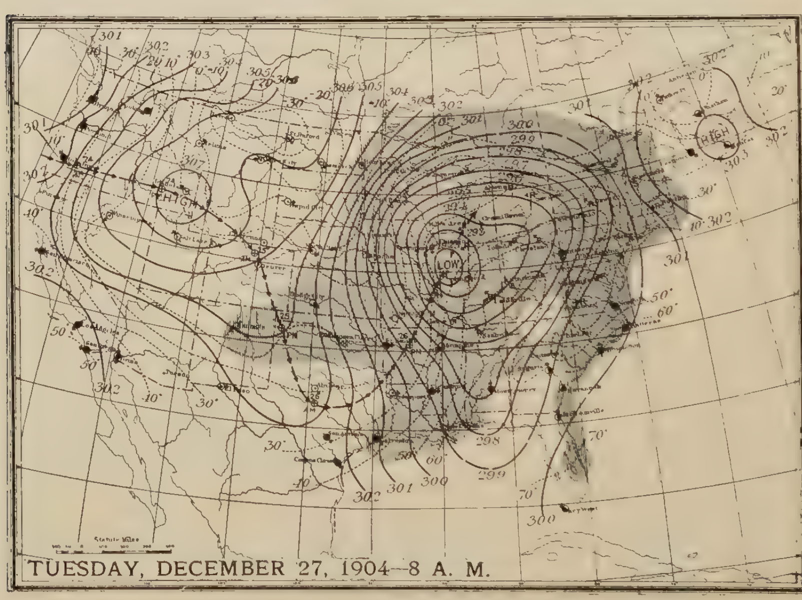


FIG. 82.

Fig. 82 shows the twenty-four-hour movement of the storm referred to in Fig. 81. Each twelve hours' progress of the storm is indicated by the small circles along its path. This is the storm mentioned in connection with Fig. 75.

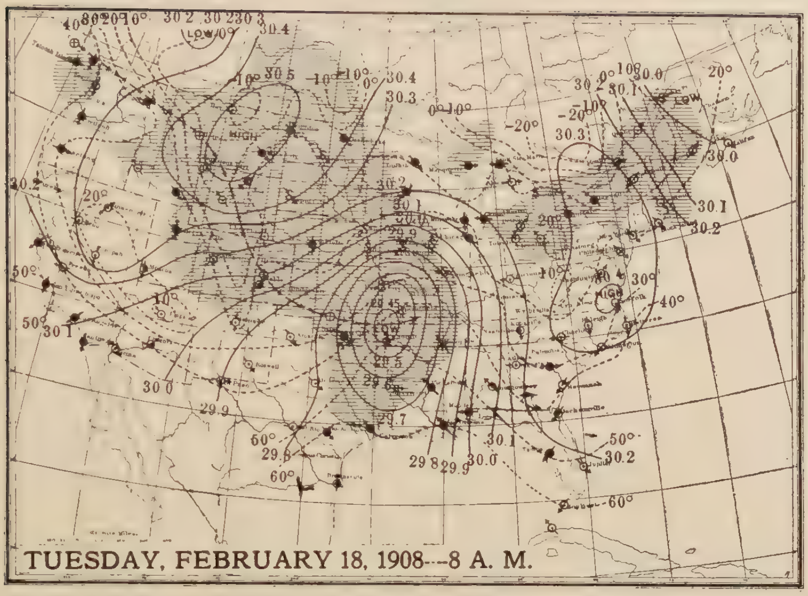


FIG. 83.

Fig. 83 shows a storm central over northwestern Arkansas on the morning of February 18, 1908. The path of this storm lay about midway between Tracks 4 and 5 (see Fig. 76). Each twelve hours' progress of the storm is indicated by the small circles along its path.

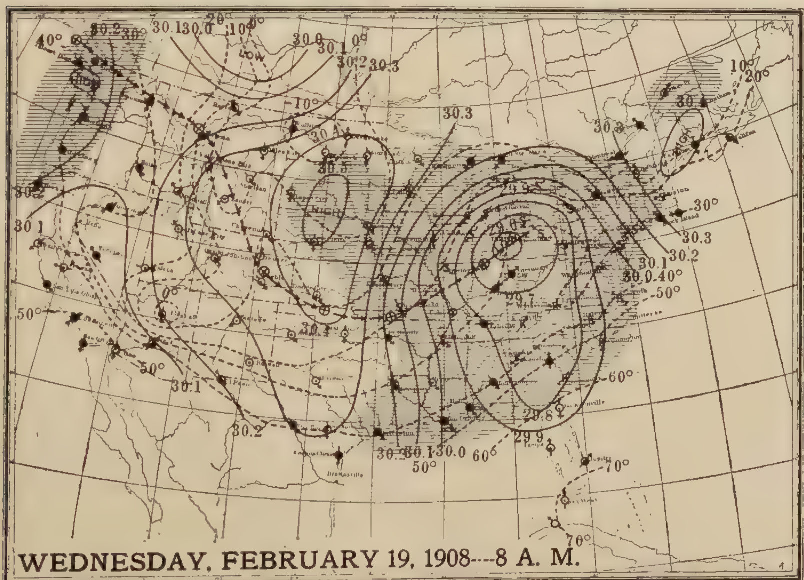


FIG. 84.

Fig. 84 shows the location of the storm referred to in Fig. 83 on the morning of February 19, 1908. This storm caused the heaviest twenty-four-hour snowfall on record at Chicago (12.7 inches).

maximum velocity of 72 miles an hour from the southwest being recorded. The storm after reaching Oklahoma passed slightly north of track 4 in Fig. 76, and, although it originated in the West Indies, its direction of movement from Oklahoma was not unlike those of the storms of December 26–27, 1904, and February 18–19, 1908, which entered the country on the north Pacific coast.

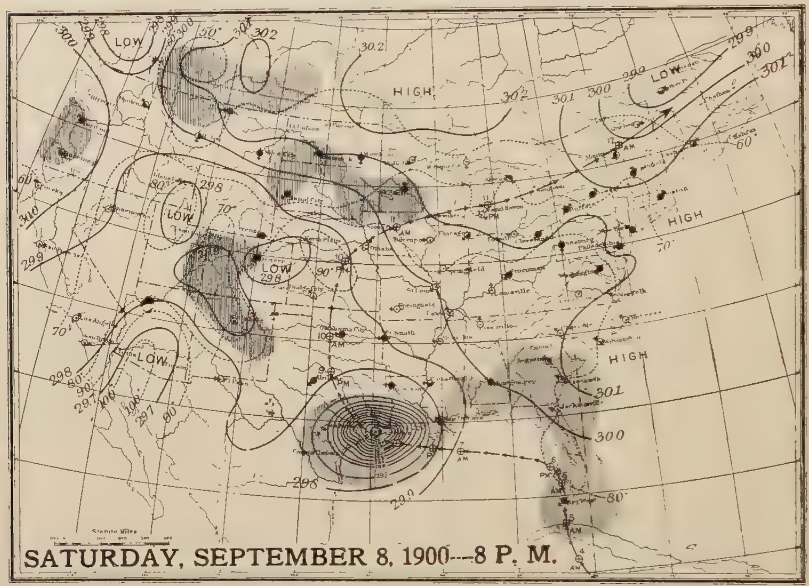


FIG. 85.

Fig. 85 shows the general weather conditions over the United States at 8:00 P.M., September 8, 1900, with the track of the "Galveston Hurricane" marked from its beginning in the West Indies on September 1, until it passed down the St. Lawrence, September 12. This storm after reaching Oklahoma passed slightly north of Track 4 (see Fig. 76).

Figs. 86, 87, and 88 show the development in spring of a high-pressure area over the Lake region. This development is due to the cold waters of the lakes lowering the temperature of the air over their surfaces, which contracts and permits more air to flow in above, finally causing a HIGH area of great magnitude covering the entire Lake region and the North-Central states. These areas in the spring are accompanied by fair and cool weather over the region of the Great Lakes for comparatively long periods, as they block the approach of storms in their normal movement from the westward.

Figs. 89, 90, 91, and 92 represent the movement of a cold wave from the far Northwest, February 11 to 14, 1899. The sea-level

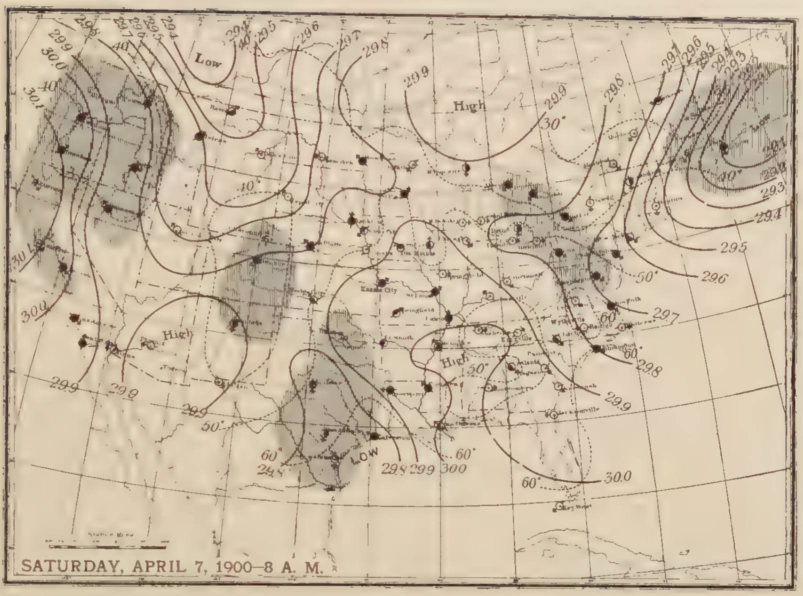


FIG. 86.

Fig. 86 shows the beginning of the development of a high-pressure area in spring over the Great Lakes region (see Figs. 87 and 88).

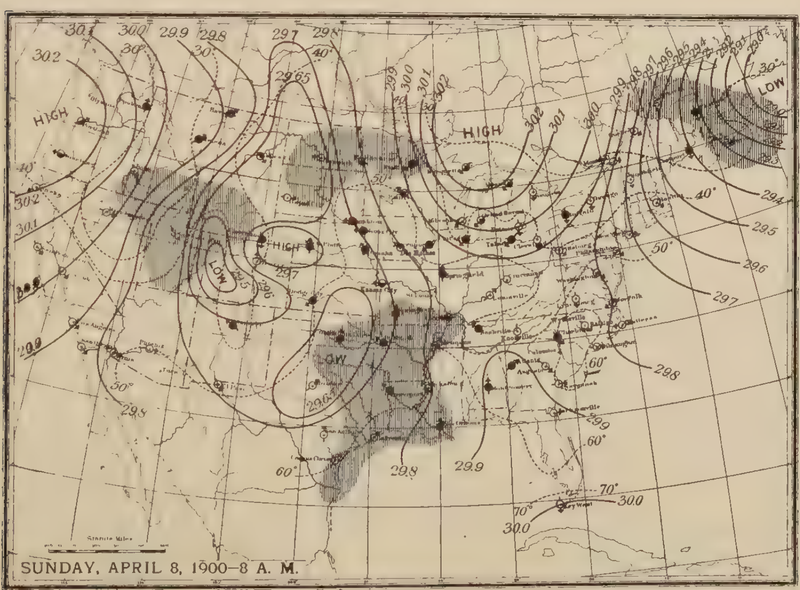


FIG. 87.

Fig. 87 shows the continued development of a high-pressure area in spring over the Great Lakes region (see Figs. 86 and 88).

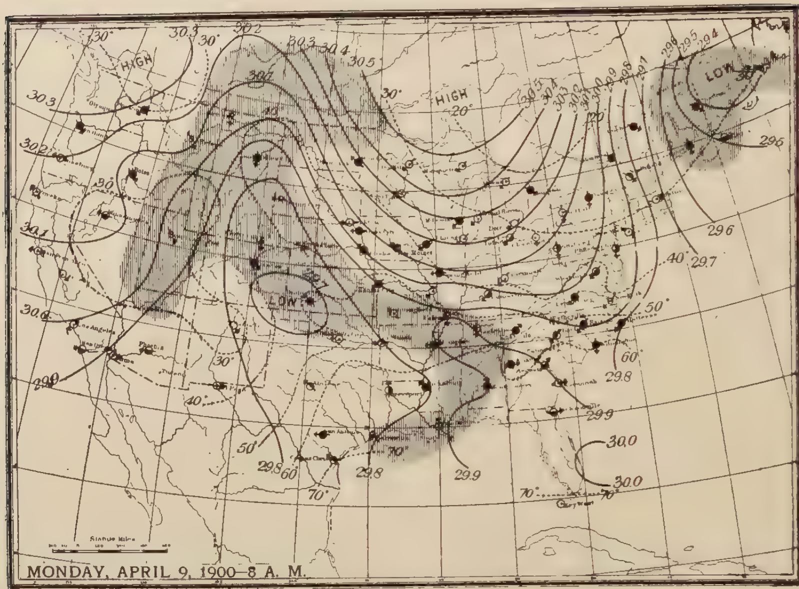


FIG. 88.

Fig. 88 shows the continued development of a high-pressure area in spring over the Great Lakes region (see Figs. 86 and 87).

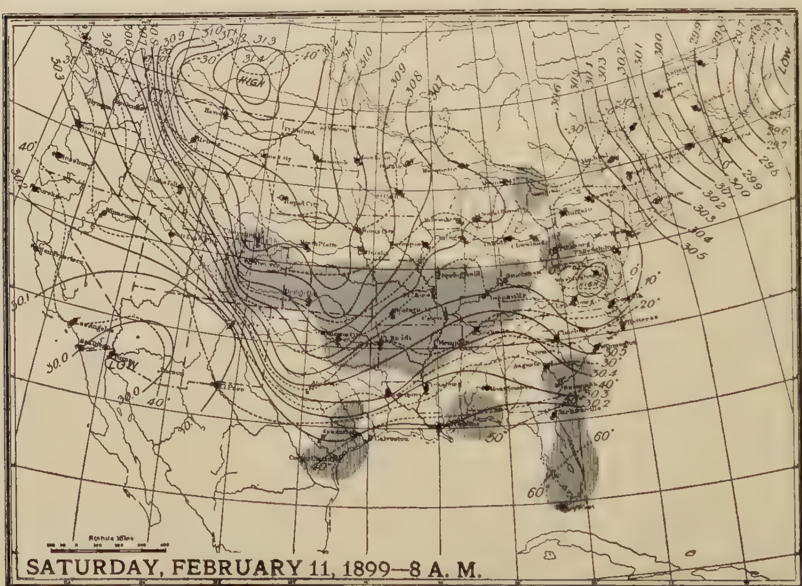


FIG. 89.

Fig. 89 shows the beginning of a cold wave in the Canadian Northwest on February 11, 1899, and its steady movement southeastward is shown by Figs. 90, 91, and 92.

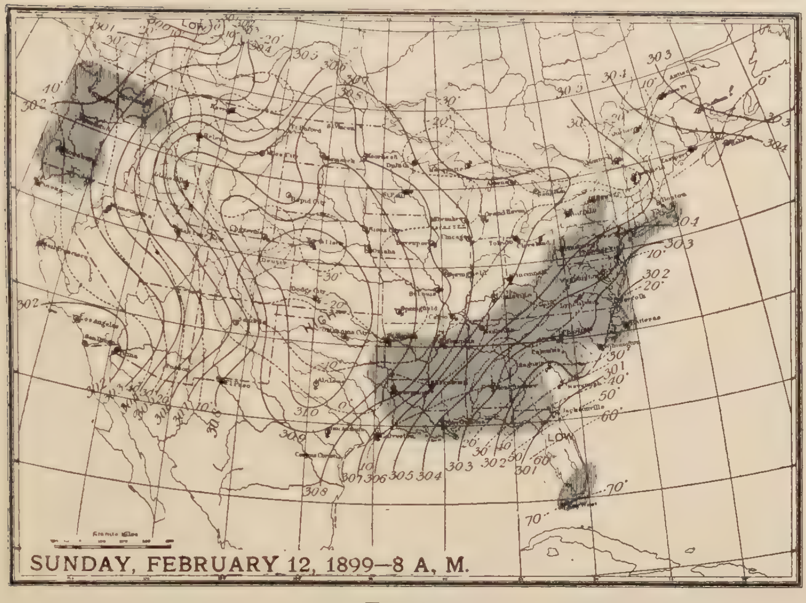


FIG. 90.

Fig. 90 shows the twenty-four-hour movement of the cold wave first noted on Fig. 89, and its continued movement southeastward is shown by Figs. 91 and 92.

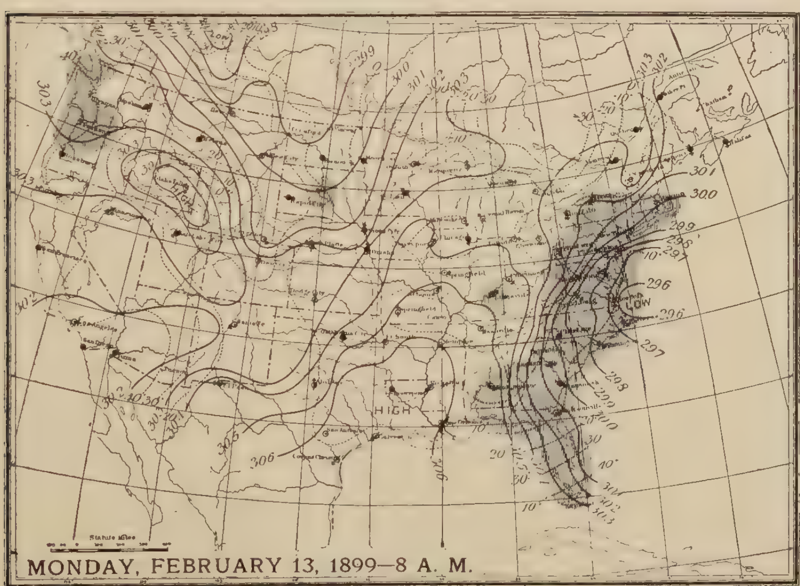


FIG. 91.

Fig. 91 shows the twenty-four-hour movement of the cold wave noted on Fig. 90 (see also Fig. 89), and its continued southeastward movement is shown by Fig. 92.

pressure of 31.4 inches, shown in the center of the HIGH in the first map of the series, is extraordinarily high, even for severe cold waves, and this area occasioned one of the coldest periods ever recorded at Chicago. The temperature on February 11 was already low over the Middle States, as well as in the Northwest. The high-pressure area in the middle Rockies shown in the third and fourth charts was rather a redevelopment, and it remained in that region for several days. By referring to the list of cold days (p. 96) it will be seen

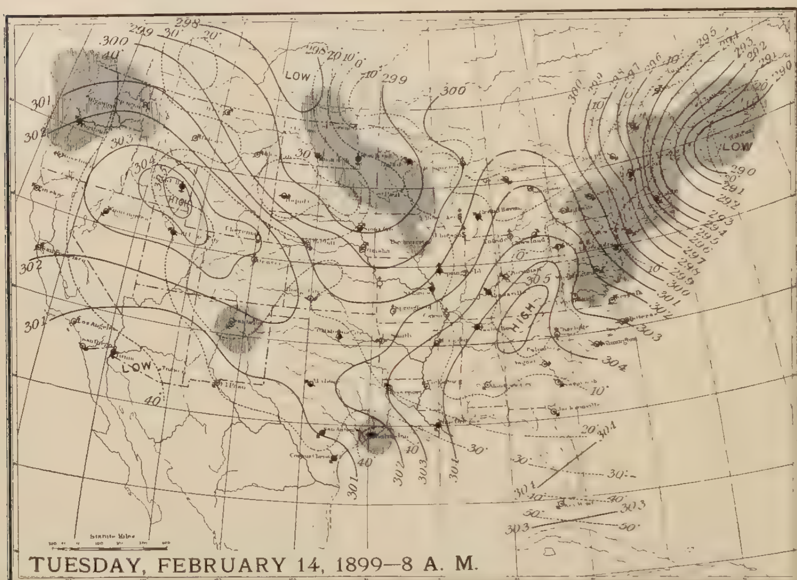


FIG. 92.

Fig. 92 shows the twenty-four-hour movement of the cold wave first noted on Fig. 89, and its position over the southeastern states on February 14, 1899 (see Figs. 89, 90 and 91).

that the temperature during this cold spell at Chicago fell below zero on 7 consecutive days, the lowest reading of the period being −21° on February 9.

Figs. 93 and 94 illustrate the movement of another cold wave from the Northwest, as shown on the weather maps of February 7 and 8, 1895. On the first day the high-pressure area was centered over North Dakota with a reading of 31.1 inches, and it moved southeastward during the following twenty-four hours. The intensity of the cold, moreover, was heightened by the development of a severe

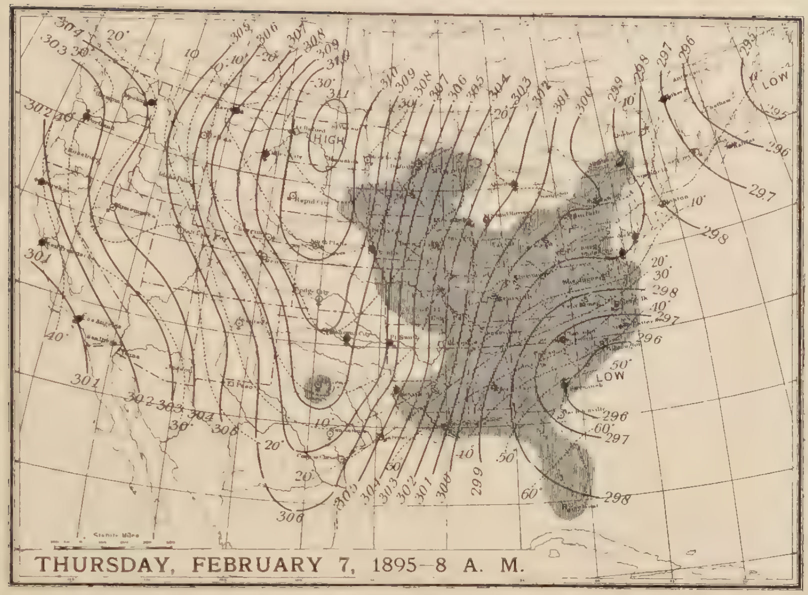


FIG. 93.

Fig. 93 shows a well-defined cold wave which subsequently moved over Chicago, giving one of the coldest periods on record.

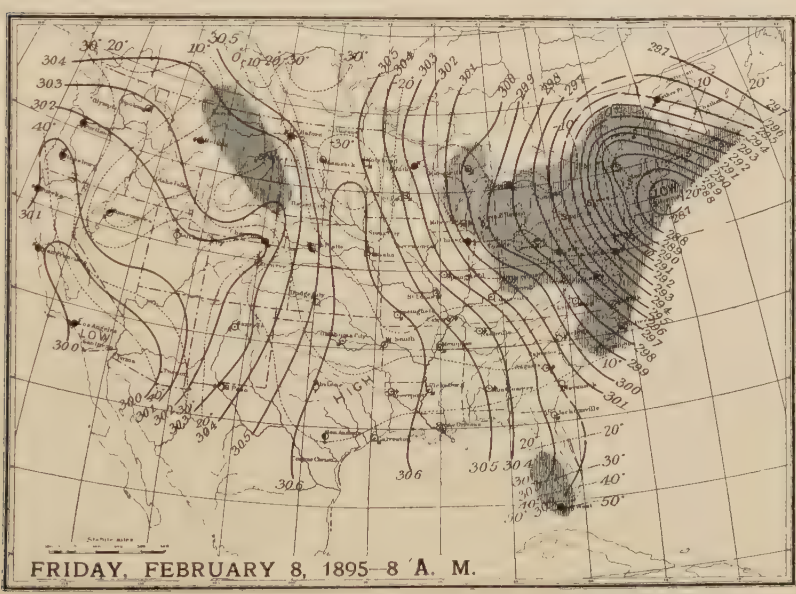


FIG. 94.

Fig. 94 shows the movement east and south of the cold wave referred to in Fig. 93. Note the development of the severe storm central off the New England coast.

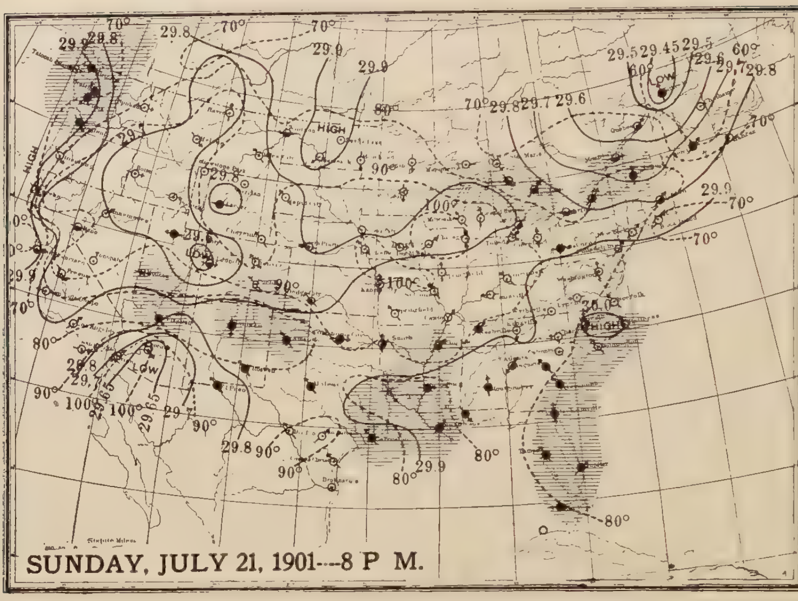


FIG. 95.

Fig. 95 shows the weather conditions prevailing over the United States at 8:00 P.M., July 21, 1901, during an intense hot wave. Note the 100° isotherms.

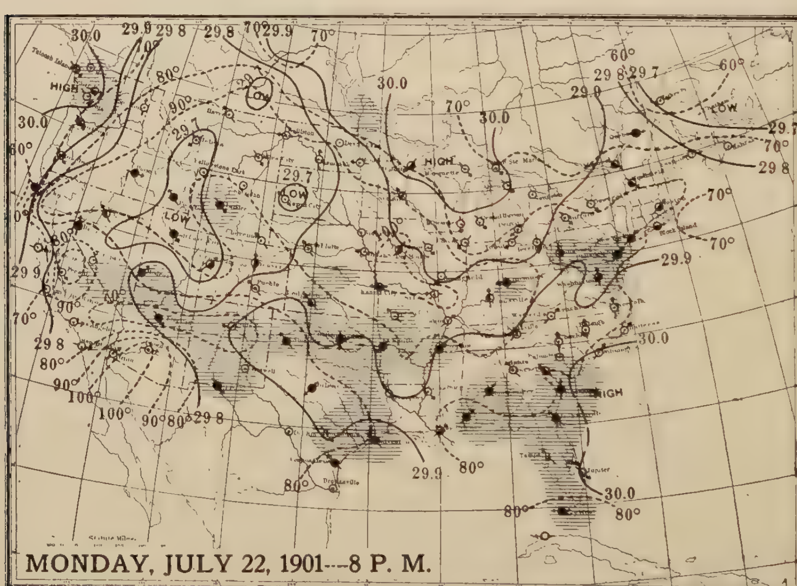


FIG. 96.

Fig. 96 shows the weather conditions prevailing over the United States at 8:00 P.M., July 22, 1901. Note the development over the Great Lakes region of an area of relatively high pressure, and the consequent lowering of the temperature in that section caused by lake winds. The hot wave still prevails in the interior.

storm which moved northeastward along the Atlantic coast, causing a well-marked gradient from the HIGH to the LOW, and consequent strong winds over the eastern half of the country. During this cold wave the temperature at Chicago reached $-15°$, and the thermometer fell to below zero on 3 consecutive days.

In the two paragraphs immediately preceding, the conditions usually attending well-marked cold waves which affect Chicago have been illustrated, and some reference to the conditions which bring about hot waves will here be appropriate. That of July, 1901, the temperature features of which have already been instanced in this volume in connection with other subjects, is an excellent example, and the general conditions are given in Figs. 95 and 96, weather maps of July 21 and 22. During the prevalence of a hot wave the barometric pressure is usually high over the South Atlantic states and relatively low over the northern tier of states and in the middle sections of the country. This distribution of pressure gives southerly winds over that portion of the United States lying east of the Rocky Mountains, as is shown on the chart of the 21st. By the evening of the 22d the intensity of the heat was broken in the Lake region by the development there of a high-pressure area, as shown on the map. The period marked one of the severest hot waves ever experienced in this country, record-breaking high temperatures occurring at many stations, the maximum at Chicago on the 21st being 103°. Further details regarding the conditions of this hot wave will be found on pp. 61, 72, and 142.

PART VIII

CONCLUSION

CONCLUSION

In the foregoing pages the weather and climate of Chicago have been discussed at length, and it is hoped that the work will prove of value for reference and to students of meteorology. Special emphasis has been laid upon extreme and unusual conditions and the changeableness of weather, and but little has been said regarding periods of settled conditions. This is because it is in exceptional incidents that people are most interested and they soon forget those of ordinary character. The conclusion should not be drawn that the climate of Chicago is not a healthful one, for it is, on the contrary, as stated previously, one well adapted for a person in health. Its snowstorms and cold waves stir the blood to renewed activities, but the latter as well as its hot waves are seldom of long duration, tempered as they usually are by the modifying influence of the waters of Lake Michigan. Its rainfall is ample and well distributed. Its humidity is moderate and in the spring and early summer, when the lake winds are most prevalent, the temperature of the air is rising, thus preventing the humidity from reaching a high point. These lake winds bring to the city the purest air, and whether the winds blow from the lake or the land, they usually have a certain briskness tending to carry away impurities and to prevent the smoke from settling over the city. The very changeableness of the weather is one of Chicago's greatest assets, as it is a potent factor in the activities of the people and in the upbuilding of the city. Many of its days in June are so perfect that one is reminded of Lowell's words, "What is so rare as a day in June?" and there are frequent periods in July equally charming, often when the country in the interior away from the lakes is sweltering in intense heat. Moreover, the longest periods of sunshiny weather usually occur in the autumn, Indian Summer appearing at its best in Chicago and vicinity. Some cities boast of an equable temperature, others, of continuous sunshine, but where there is no changeableness the weather must become most monotonous. Because of marked variations in weather, fine, pleasant days are all the more appreciated, and the statistics show that Chicago has its full share of these.

APPENDIXES

APPENDIX I

WEATHER OF HOLIDAYS

WEATHER OF NEW YEAR'S, FOURTH OF JULY, AND CHRISTMAS

Unusual interest attaches to the more important of our holidays, and in order to furnish information as to the local character of these days in past years, the conditions have been sketched out in Figs. 97, 98, and 99 from the data given in Table CXLVI, covering the period from 1872–1913, inclusive.

Thanksgiving Day, being a movable holiday, has not been included in the table or the graphs. It should be understood, of course, that the weather of these respective days in former years can in no wise be taken as a certain indication of their character in the future.

New Year's Day has been clear 11 times during the period shown, while Christmas Day has been clear but 6 times. The occurrence of cloudy weather on these days was 20 and 26 times, respectively, and the remainder were partially overcast.

The Fourth of July, occurring in the height of the summer season, has experienced but few cloudy days, only 6 in all, while on 18 occasions the weather has been clear, and the remainder partly cloudy.

Minimum temperatures have been below zero but twice on both New Year's Day and Christmas Day, and no very low temperatures have occurred on either day. The warmest weather for these days was 65° for New Year's Day, 1876, and 56° for Christmas Day, 1895. The greatest depth of snow on the ground at Christmas occurred in 1909, 8.0 inches, records extending back to the Christmas of 1893 only. Out of the 21 years shown in this record, there has been no snow on the ground on this date in 6 years, and in 4 of the 20 years only an unmeasurable amount, represented by "T" in the table, has been recorded.

On the Fourth of July, the highest temperature was 102° in 1911; 95° occurred in 1901, and from 90° to 94° has been observed in 5 other years. On New Year's Day there have been 12 days with

TABLE CXLVI

WEATHER OF NEW YEAR'S DAY, FOURTH OF JULY, AND CHRISTMAS, 1872–1913

Year	New Year's Day (25°) Temperature Max.	Min.	Dept. of Mean	Weather State	Precipitation	Wind P.D.	Wind Vel.
1872......	......	......	......	......	......	......	......
1873......	30	19	1	⊕	.01	E	5
1874......	43	35	**14**	⊕	......	S	12
1875......	40	29	**9**	⊕	.01	SW	6
1876......	65	40	**27**	⊕	.44	SW	14
1877......	24	6	10	⊕	......	W	9
1878......	37	30	**9**	⊖	.02	NW	7
1879......	25	8	9	⊕	.03	W	3
1880......	42	26	**9**	○	......	S	12
1881......	29	10	5	○	......	SW	7
1882......	27	16	3	○	T	NW	9
1883......	24	12	7	⊖	.01	W	8
1884......	31	22	**1**	⊕	.30	NE	16
1885......	16	3	15	⊖	......	W	12
1886......	48	36	**17**	⊖	......	S	7
1887......	16	− 6	20	⊖	......	NW	7
1888......	34	7	5	⊖	T	SW	26
1889......	39	18	**3**	⊖	......	SW	15
1890......	54	33	**19**	⊕	.48	S	14
1891......	54	36	**20**	⊕	1.25	NE	24
1892......	55	41	**23**	⊕	.57	S	31
1893......	30	22	**1**	⊕	T	NW	16
1894......	42	28	**10**	⊕	......	SW	23
1895	25	12	7	○	......	NW	10
1896......	30	10	5	⊖	......	S	24
1897......	57	43	**25**	⊕	.04	S	23
1898......	20	12	9	○	......	NW	18
1899......	16	0	17	○	......	SW	15
1900......	18	2	15	○	T	NW	15
1901......	15	− 5	20	○	......	W, SW	16
1902......	34	24	**4**	⊖	......	SE	21
1903......	42	25	**9**	○	......	SW	16
1904......	27	20	1	⊕	......	NE	22
1905......	48	36	**17**	⊕	......	SW	18
1906......	33	22	**3**	⊕	......	SE	5
1907......	34	28	**6**	⊕	......	W	12
1908......	37	22	**5**	○	......	N	9
1909......	24	14	6	⊕	T	W	11
1910......	40	32	**11**	⊕	......	SW	17
1911......	42	35	**13**	⊕	.06	S	17
1912......	17	6	13	○	T	SW	12
1913......	43	32	**13**	⊖	......	S	13

Year	July 4 (71°) Temperature Max.	Min.	Dept. of Mean	Weather State	Precipitation	Wind P.D.	Wind Vel.
1872	70	56	8	○	......	N	13
1873	78	61	1	⊖	1.35	SW	8
1874	72	66	2	○	......	NE	12
1875	82	66	**3**	⊖	.31	NE	5
1876	80	67	**3**	⊖	.29	SE	6
1877	82	68	**4**	⊖	......	SE	6
1878	72	63	3	⊖	......	NE	5
1879	80	64	**1**	⊖	T	NE	8
1880	82	65	**3**	⊖	.48	S	6
1881	89	66	**7**	○	......	W	8
1882	63	56	11	○	.01	N	12
1883	90	68	**8**	⊖	1.60	SW	9
1884	68	61	7	⊕	.18	E	5
1885	77	64	1	⊖	.03	SE	3
1886	84	67	**5**	○	......	SE	6
1887	83	68	**5**	⊖	.09	W	12
1888	86	65	**5**	⊕	1.02	NE	7
1889	72	57	7	○	......	SE	7
1890	65	58	9	○	......	NE	29
1891	73	59	5	○	......	NE	14
1892	71	58	7	⊕	.09	SE	6
1893	80	62	**0**	⊖	T	S	20
1894	72	61	5	○	......	NW	13
1895	74	63	3	○	......	E	9
1896	75	64	1	○	......	NE	13
1897	94	78	**15**	○	......	SW	25
1898	68	62	6	○	......	NE	13
1899	74	64	2	⊕	.85	S	12
1900	91	75	**12**	○	......	SW	19
1901	95	75	**14**	○	.01	SW	15
1902	89	74	**11**	○	......	SW	20
1903	91	70	**9**	⊖	.28	S	22
1904	80	70	**4**	⊖	T	SW	24
1905	74	68	**0**	⊕	.08	SW	25
1906	72	60	5	○	......	N	15
1907	78	65	**1**	⊖	......	NE	11
1908	79	64	**1**	⊖	T	SW	13
1909	63	58	11	⊕	.03	NE	8
1910	69	62	5	⊖	......	N	18
1911	102	78	**19**	○	......	S	8
1912	89	70	**9**	⊖	T	SW	10
1913	94	77	**15**	⊖	......	SW	13

Year	Christmas (27°) Temperature Max.	Min.	Dept. of Mean	Weather State	Precipitation	Wind P.D.	Wind Vel.	Depth of Snow on Ground (Inches)
1872	20	4	15	⊕	......	E	9	....
1873	38	33	**9**	⊕	......	S	7	....
1874	43	23	**6**	⊖	......	SW	12	....
1875	43	30	**9**	⊕	......	W	9	....
1876	28	21	3	⊕	.03	E	5	....
1877	50	42	**19**	⊕	.34	N	11	....
1878	15	3	18	○	......	SW	10	....
1879	15	2	19	⊖	.34	W	10	....
1880	34	28	**4**	⊕	.01	N	4	....
1881	44	35	**13**	○	......	SW	10	....
1882	40	33	**9**	⊕	.22	E	5	....
1883	32	24	**1**	⊖	......	SW	9	....
1884	18	8	14	⊕	.11	W	5	....
1885	37	30	**7**	⊕	.02	NE	9	....
1886	35	18	1	⊖	.17	SE	5	....
1887	23	14	9	⊕	T	SW	10	....
1888	39	35	**10**	⊕	.02	N	23	....
1889	47	33	**13**	⊖	......	SW	7	....
1890	28	20	3	⊕	......	E	22	....
1891	52	34	**16**	⊕	T	SW	25	....
1892	10	− 2	23	⊖	.03	NW	21	....
1893	52	30	**14**	⊕	.03	SW	30	T
1894	31	24	**1**	○	.01	NW	16	0
1895	56	33	**17**	⊕	.06	SW	25	0
1896	31	15	4	⊖	......	SW	25	0.1
1897	32	18	2	⊕	......	SW	25	1.0
1898	29	26	**1**	⊕	.05	NE	16	0.9
1899	15	6	17	○	......	NW	20	0
1900	18	12	12	⊕	T	W	17	2.0
1901	35	29	**5**	⊕	.16	SW	12	2.0
1902	10	5	19	⊖	T	NW	20	1.7
1903	30	− 2	13	⊕	.26	NW	18	4.7
1904	29	25	**0**	⊕	.02	E	13	0.2
1905	34	24	**2**	⊖	......	W	12	T
1906	34	26	**3**	⊖	......	NW	8	T
1907	39	31	**8**	⊕	......	SW	18	3.5
1908	35	27	**4**	⊕	......	NW	19	0
1909	31	23	**0**	⊕	.50	NW	20	8.0
1910	32	13	5	⊕	.03	S	16	0.3
1911	37	32	**7**	○	......	W	11	0
1912	43	32	**11**	○	......	SW	15	0
1913	38	34	**9**	⊕	......	N	18	T

Normal temperature: New Year's Day, 25°; July 4, 71°; Christmas, 27°. ○, clear; ⊖ partly cloudy; ⊕ cloudy.

Table CXLVI shows the character of the weather prevailing on each New Year's Day, Fourth of July, and Christmas, from July 4, 1872, to and including Christmas, 1913. The first two columns in each case show the maximum and minimum temperature, the third, the departure from the normal temperature, expressed above in parentheses. Bold-faced figures indicate departures above normal, light-faced figures, departure below normal. The fourth column indicates the weather, ○ for clear, ⊖ for partly cloudy, and

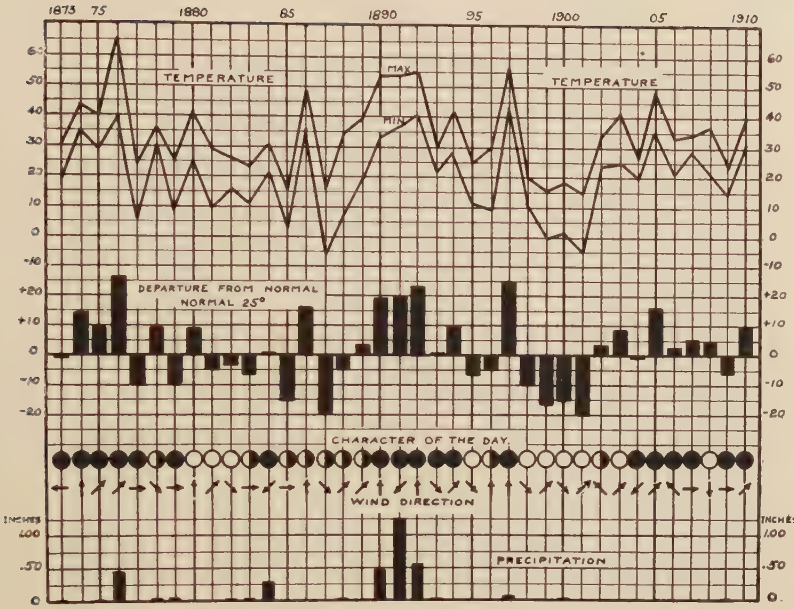


Fig. 97.—The weather of New Year's Day (see Table CXLVI).

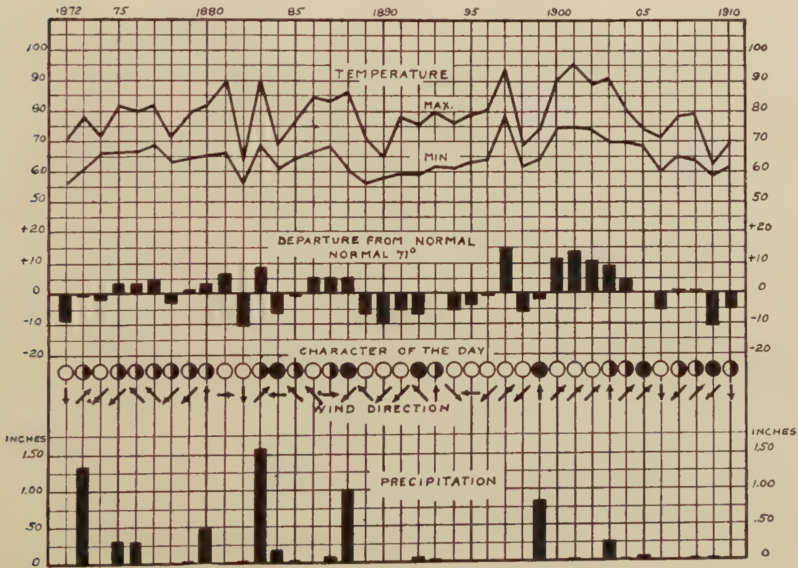


Fig. 98.—The weather of July 4 (see Table CXLVI).

appreciable precipitation; on Christmas Day, 19; and on the Fourth of July, 16 such days. On the latter, the rains were chiefly those of

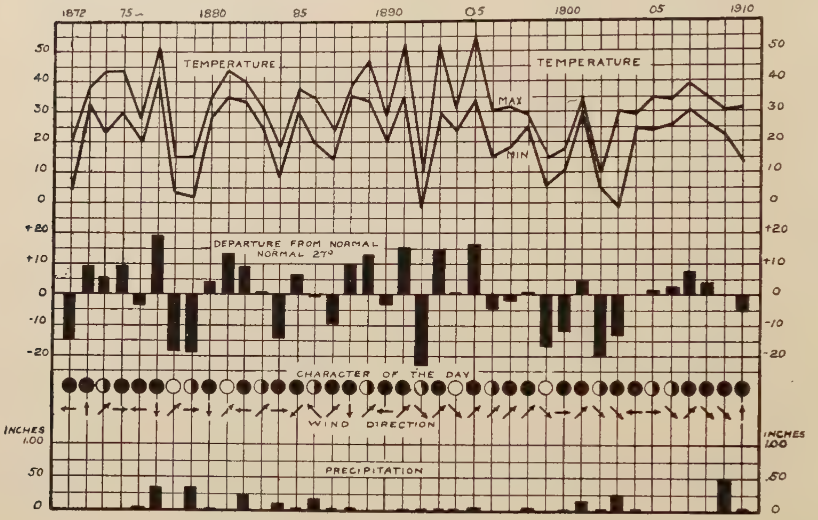


Fig. 99.—The weather of Christmas Day (see Table CXLVI).

thunderstorms and were of short duration, but the precipitation was heavy on three occasions, exceeding 1 inch in 1873, 1883, and 1888.

APPENDIX II

COMPARATIVE DATA ON TEMPERATURE AND PRECIPITATION FOR VARIOUS CITIES OF THE WORLD

Table CXLVII contains for comparative purposes data of rainfall and temperature for various cities of the world. An attempt has been made to verify the accuracy of the data for the cities in foreign countries, but it is possible that correct information has not in all cases been secured. The entries, however, are the best obtainable, and they have been brought down to date as far as has been practicable.

TABLE CXLVII

SHOWING COMPARISON OF RAINFALLS AND TEMPERATURES OF VARIOUS CITIES OF THE WORLD

City	Height above M.S.L. Ft.	Annual Rainfall			Temperature					
		Average (a)	Highest (b)	Lowest (c)	Average Summer (d)	Average Winter (e)	Highest Recorded (f)	Lowest Recorded (g)	Average of Warmest Month (h)	Average of Coldest Month (i)
Amsterdam	....	27.28	40.59	17.60	63.1	36.7	90.0	4.1	64.2	35.4
Athens	351	15.37	33.33	4.56	78.4	50.4	106.5	19.6	81.7	49.3
Berlin	161	22.80	27.18	17.97	64.6	32.4	97.5	− 9.6	65.8	30.6
Berne	1880	46.00	58.23	24.68	62.2	29.8	91.4	− 3.6	64.4	28.0
Bombay	37	73.99	....	....	80.4	75.2	98.5	55.9	84.6	74.0
Brussels	177	28.60	47.00	20.00	63.2	37.2	....	....	65.0	35.6
Budapest	502	24.80	35.28	12.91	68.5	30.2	100.8	− 5.1	70.3	28.2
Buenos Ayres	72	35.20	78.74	22.76	75.4	51.4	103.1	28.4	75.0	50.0
Cairo, Egypt	108	1.26	2.10	0.30	82.4	56.0	112.3	30.7	84.2	53.6
Calcutta	21	60.83	....	....	83.3	66.9	108.2	44.2	85.7	65.0
Capetown	40	25.50	36.72	17.71	68.1	54.7	102.0	34.0	68.8	53.9
Chicago	595	33.52	45.86	24.52	69.2	25.4	102.9	−23.0	72.4	23.7
Christiania	82	22.52	31.73	16.26	54.4	29.5	95.0	−21.1	62.6	23.9
Colomba	40	88.27	....	....	80.3	79.3	100.0	64.0	82.5	79.0
Constantinople	246	28.75	42.74	14.78	74.0	43.5	103.6	13.0	75.7	42.0
Copenhagen	46	21.80	27.87	21.58	60.5	31.9	90.5	− 9.7	61.9	31.4
Dublin	155	29.20	35.57	20.47	58.9	42.0	87.0	13.0	63.9	32.8
Edinburgh	441	25.00	32.89	16.50	59.0	38.4	88.0	0.0	....	37.0
Genoa	180	52.83	74.96	35.98	73.6	46.9	94.5	16.7	75.4	45.5
Hong Kong	110	84.88	100.00	57.03	80.9	59.1	92.9	40.6	80.9	55.3
Honolulu	38	23.20	30.13	16.99	76.7	71.2	86.0	56.0	77.6	70.2
Johannesburg	5925	30.64	40.39	21.66	65.0	51.5	94.0	23.3	66.8	40.6
Lisbon	335	31.00	102.00	27.50	69.6	51.3	94.1	32.5	70.9	50.4
London	154	24.36	34.08	16.93	61.2	39.3	97.1	4.0	62.7	38.6
Madras	22	49.00	88.66	18.45	87.3	76.7	112.0	57.0	89.3	76.1
Madrid	2149	17.99	27.48	11.22	73.0	41.2	107.1	10.5	75.7	39.7
Manila	46	76.30	117.30	35.70	81.0	77.7	100.0	60.3	83.5	77.0
Marseilles	246	21.73	43.05	12.05	70.3	46.0	100.4	11.5	83.0	....
Melbourne	91	26.16	44.25	15.16	65.0	49.9	111.2	27.0	67.5	48.5
Naples	187	33.60	44.17	16.35	73.6	48.0	99.1	23.9	75.6	46.8
New Orleans	51	55.74	85.73	31.07	81.7	55.5	102.0	7.0	82.2	54.1
New York	175	44.11	58.68	35.73	72.2	31.8	100.0	− 6.0	74.1	30.7
Ottawa	294	33.05	44.44	25.63	66.4	13.4	98.5	−33.0	69.0	11.3
Paris	104	19.68	26.18	15.28	63.0	38.4	101.1	−14.0	66.0	36.3
Pekin	125	24.96	....	....	77.2	27.1	....	24.8	78.8	23.5
Quebec	293	40.84	52.39	32.12	64.0	12.3	96.0	−34.3	66.7	9.8
Rio de Janeiro	197	46.84	63.35	4.72	76.8	68.2	102.2	50.4	78.1	67.5
Rome	164	35.50	57.89	21.48	74.5	45.7	99.1	21.2	76.6	44.1
San Francisco	28	22.50	38.70	9.30	59.0	51.0	100.0	29.0	61.0	50.0
Shanghai	23	43.66	57.57	27.92	78.1	39.9	102.9	10.2	80.6	37.0
Singapore	....	92.76	123.24	65.56	80.9	78.6	100.8	63.7	81.5	78.3
Stockholm	148	18.62	28.27	11.77	59.5	27.3	96.8	25.6	61.9	26.1
St. Louis	567	37.36	49.20	23.38	77.1	34.0	107.0	−21.5	79.2	31.2
St. Petersburg	16	20.86	25.11	15.74	61.0	19.0	87.4	−30.3	64.0	17.1
Tokio	62	60.08	77.10	45.75	73.8	39.0	97.9	15.4	77.7	37.2
Valparaiso	164	13.78	....	....	61.9	52.5	....	....	63.1	52.5
Vienna	666	24.53	35.51	16.54	65.7	33.6	101.7	−13.9	67.1	28.0
Vladivostok	98	13.23	22.30	9.60	64.2	15.6	93.4	−27.0	69.6	5.7
Washington	73	43.10	61.30	30.60	75.0	35.0	104.0	−15.0	77.0	33.0

(a) Average annual rainfall in inches and hundredths.

(b) Highest annual rainfall in inches and hundredths.

(c) Lowest annual rainfall in inches and hundredths.

(d) Mean summer temperature, degrees Fahrenheit.

(e) Mean winter temperature, degrees Fahrenheit.

(f) Highest temperature on record, degrees Fahrenheit.

(g) Lowest temperature on record, degrees Fahrenheit.

(h) Average hottest month, degrees Fahrenheit.

(i) Average coldest month, degrees Fahrenheit.

APPENDIX III

JOURNAL ENTRIES RELATIVE TO THE CHICAGO FIRE, OCTOBER 8 AND 9, 1871

In the preparation of this bulletin the Daily Journal of the Weather Bureau office was searched for any special information that might be of interest or value to the reader. The notes therein descriptive of the great Chicago Fire in October, 1871, from a meteorological standpoint have a peculiar interest, and this publication would hardly be complete without them. It will be remembered that the fire occurred following a prolonged drouth (p. 197). The Weather Bureau office had been in operation at that time about one year, and the records for that period were lost, as well as the instrumental equipment of the office. The entry is as follows:

October 16. Took possession of new office, No. 10 West Randolph Street, yesterday. Have been without records from October 8 until today, everything official having been destroyed by the great fire, October 8 and 9. The observation at 10:53 P.M., October 8, was taken and transmitted as usual. At half-past nine an alarm of fire was rung. There had been a very large fire the preceding night, which had been subdued with difficulty. The weather was intensely dry, and the wind blowing from the south-south-west with a velocity of about twenty miles an hour. Accordingly when by 10 P.M. the fire had increased instead of diminishing, many people turned out to see it, not from alarm, but simply for the sake of the spectacle. At 10:30 the fire was still confined to two blocks, with a strong hold of only one. The firemen at this time seemed to have a fair chance of checking it; still the burning was so great as to enable one, by the light of it, to read the time on the city clock, one and one-half miles distant. The wind was carrying sparks right through the center of the city, the line lying only two blocks west of the city hall. Still no one felt alarmed, except those in the immediate vicinity. I, myself, was present, and had seen the much larger fire of the preceding night checked by the river. At 12 P.M. the fire had increased considerably in area and intensity, but as the wind was south-southwest, and the river ran due north and south, there seemed as yet but little danger to anything beyond the river. Hitherto the fire had been extended, and with no great velocity, merely by contact with the flames, but toward 1 A.M. the heat had become so intense as greatly to increase the power in the immediate neighborhood of the flames. This was especially the case on the east and west of the fire toward the front, the wind blowing straight toward

the fire in all directions. Within forty yards of the blaze I estimated the wind toward it at thirty miles an hour. This caused a decided whirling motion in the column of flame and smoke, which was contrary to that of the hands of a watch.

Blazing pieces of timber of considerable size were now whirled aloft and carried to the north-northeast, starting new fires as they fell. These new fires, being in the line of the smoke, were invisible to those at the old fire. One of the fires was on the east side of the river, only a few blocks from the courthouse. By 2 o'clock the courthouse with all the beautiful buildings around it was in flames. The conflagration was now advancing in the line of the wind as fast as a man could walk. By 3 A.M. the waterworks, two miles to the northeast of the courthouse, were burned. The city having thus been divided in two by a sheet of flame, the fire continued to work its way more leisurely to the east and west, at right angles to the wind, as well as right in the teeth of it. The fire on the night of the 7th alone saved the west division, as it had burned two blocks in width down the west side of the river. The fire on the 8th originated only a few blocks farther south, hence it could not progress north for want of material. On the east side of the river in the south division, the fire continued to work toward the east; and this it did with the greatest rapidity at the southern limit of the conflagration, because there the unburned houses broke the wind and caused a back current at the base of the buildings. As soon as the fire had thus got a new swath of houses before it, and the wind behind it, away it went tearing, sadly surprising many who were congratulating themselves because the first rush of flame had spared them.

The *Tribune* people thought the strength of their building had saved them, because it lay at the extremity of one of the swaths. The next one took it. In the north division the first rush of the fire reached the lake, and then it worked its way west to the river. This it did not accomplish before 12 noon on the 9th. The wind by 9 A.M. had increased to perhaps twenty-five miles an hour, at the distance of three miles to the southwest of the fire. In the immediate vicinity of it, especially in streets running east and west, it was blowing with the force of a hurricane, on the north side lifting up whole burning buildings and pitching them upon the tops of others. The wind blowing in all directions toward the fire, confused some people in their endeavors to escape. This also caused the fire to progress along the tops of buildings before the wind, and along the bases of buildings against the wind. The heat was intense. The buildings in front and at the sides of the fire began first to smoke from the heat radiating from the burning. Then in many cases, without waiting for a tongue of flame to touch them, they would all at once burst into a blaze. To talk of fireproof buildings in the midst of such a furnace is absurd. Steel was melted in innumerable cases, and stones and brick were burned to powder.

The firemen at first endeavored to check the fire in front, but as soon as it had gathered in force this was not to be thought of; not a single drop of water could reach the fire. The wind swept it aloft. Besides, the firemen had to look out. Several of the engines which went to the front at first were burned; others made futile efforts along the side of the fire, playing at right angles to the wind. The fire ate in behind them, and they had to run. I saw several engines, before the water stopped, doing nothing. At length they saw what they could do and confined themselves to that. Letting the fire have free scope to the north and east, they endeavored to prevent it spreading to the south against the wind. In this they succeeded, cutting it off just as it was laying hold of immense piles of lumber which lay along the river. This was done about 3 A.M., Monday. The efforts of the firemen, lamed for want of water, were ably seconded by gunpowder in the forenoon, in the south division. The same agent had been employed to check the northward progress of the fire, but in vain. Toward noon, its farther progress southward was thus checked. In the northern division it had reached its limits at about the same time, having burnt everything that would burn, out as far as Lincoln Park, about four miles from the courthouse.

The loss of life was greatest along the path of the first rush of the fire; it came so suddenly and unexpectedly. Only those who died in the streets have been recovered. The very bones of those who were in the buildings were burned.

The observation office lay right in the path along which the conflagration moved its first swath, from the southwest through the center of the city to the northeast. I went to the scene of the fire between 10 and 11 P.M., and did not think of the danger until too late. Kaufman was on duty and saved most of the valuable instruments, but only for a time. He carried them to his lodgings, which lay nearer the lake, and returned to find all the buildings around the office in a blaze. Thinking himself safe he went back to his lodgings and went to sleep, and awoke in time to find the flames just upon him. Snatching his trunk he escaped to the lake. Many trunks were lying there in flames, and he pitched his into the water. It might have been possible to save everything by procuring a vehicle at the first; but vehicles were scarcely to be had. A jeweler, only a block from the observation office, is said to have offered in vain a thousand dollars for one.

APPENDIX IV

NOTES RELATIVE TO DATA, OBSERVATIONS, INSTRUMENTS, OFFICIALS IN CHARGE, AND FORECAST SERVICE

When the Government Weather Bureau office was first established in Chicago on October 15, 1870, it was under the jurisdiction of the Signal Service of the United States army, but it was transferred to the Department of Agriculture on July 1, 1891. Since the beginning of the work observations have been maintained continuously to the present time, except for a period of fourteen days in October, 1871, immediately following the Great Fire. The records used in this bulletin for periods previous to this time, extending for temperature back to 1830 and for precipitation to 1843, are taken from Hazen's *Climate of Chicago*, as stated previously (pp. 4, 151). Being drawn in some measure from outside sources by interpolation, and from observations the environments of which are now unknown, the accuracy of these early data cannot be vouched for, and too much dependence should not be placed upon them. Some of the observations were taken at the University, others at various places in the city or in the suburbs, and some in near-by towns. Since its establishment in 1870, the Weather Bureau office has been moved several times, the various locations, with the heights of the different instruments, being as follows:

APPENDIX TABLE A

Date	Location	Height of				
		Barometer above Sea Level	Thermometer above Ground	Rain Gage above Ground	Anemometer above Ground	Wind Vane above Ground
October 15, 1870	162 East Washington St.	651	57	*	*	*
May 1, 1871	164 East Washington St.	651	57	67*	85*	85*
October 15, 1871	10 West Randolph St.	633	32	43	72	72
June 11, 1872	80 South Market St., Central Block	667	74	97	108	113
June 8, 1873	S.E. corner Madison and LaSalle Sts., Major Block†	661	70	93	103	108
January 1, 1887	S.W corner Clark and Washington Sts., Chicago Opera House	715	146	132	153	155
February 1, 1890	Auditorium Tower	823	241	238	274	272
July 1, 1905	Federal Building	816‡	140	133	310	312

* Unknown or uncertain.

† At present called the Roanoke Building, with two added stories.

‡ All readings at this elevation, however, are reduced to the station elevation of 823 feet (p. 321).

The various officials who have had charge of the Chicago Weather Bureau office, and the dates of their assignments, are as follows:

James Macintosh	October	15, 1870	to July	17, 1872
Theodore Mosher	July	17, 1872	to January	2, 1873
A. C. Ford	January	2, 1873	to May	1, 1876
C. E. Brinsmade	May	1, 1876	to November	6, 1877
S. S. Bassler	November	6, 1877	to December	21, 1877
J. M. Clifford	December	21, 1877	to January	23, 1878
J. J. Lynch	January	23, 1878	to January	9, 1880
James Mitchell	January	9, 1880	to March	8, 1883
John Laurens	March	8, 1883	to June	26, 1883
William Norrington	June	26, 1883	to March	18, 1884
T. B. Jennings	March	18, 1884	to July	25, 1885
Allen Buell	July	25, 1885	to December	1, 1887
H. C. Frankenfield	December	1, 1887	to May	15, 1894
Willis L. Moore	May	15, 1894	to July	1, 1895
E. B. Garriott	July	1, 1895	to August	1, 1898
Henry J. Cox	August	1, 1898,	in charge at present	

First storm warning issued.—Professor Increase A. Lapham, of Milwaukee, Wis., a man who was foremost in the efforts to establish a national weather service in this country, was specially assigned to the Chicago office in November, 1870, as forecaster, and he remained here for several months. To him belongs the distinction of having issued the first storm warning ever sent out by the Weather Bureau to vessel men, on either the Great Lakes or the oceans. This was issued on November 8, 1870, and is said to have been fully justified. It read as follows:

CHICAGO, NOVEMBER 8, 1870, *Noon.* A high wind all day yesterday at Cheyenne and Omaha. A very high wind reported this morning at Omaha. Barometer falling, with high wind at Chicago and Milwaukee. Barometer falling and thermometer rising at Chicago, Detroit, Toledo, Cleveland, Buffalo, and Rochester. High winds probable along the lakes.

During the greater portion of the period previous to 1891, the general forecasts of the Weather Bureau and the storm warnings for the Great Lakes were issued at Washington, but with the transfer of the Bureau from the Signal Service to the Department of Agriculture, various small forecast districts were established, the Chicago office at first controlling northern Illinois and northwestern Indiana. In May, 1894, these small forecast districts were merged into a few large ones, that of the Chicago office extending from the Great Lakes to the Rocky Mountains. Forecasts for that region have been issued each morning since at Chicago.

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